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ENVIRONMENTAL ASSESSMENT FOR REPACKAGING, OVERPACKING AND SHIPPING OF FMPC INVENTORIED THORIUM MATERIALS TO THE NEVADA TEST SITE

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November, 1987

ENVIRONMENTAL ASSESSMENT FOR REPACKAGING, OVERPACKING AND SHIPPING OF FMPC INVENTORIED THORIUM MATERIALS TO THE NEVADA TEST SITE

Feed Materials Production Center
Fernald, Ohio

U. S. Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee

FMPC

NEPA DOCUMENTATION

COGNIZANT PROJECT ENGINEER	S. W. Heisler, Jr.
PROJECT LOCATION	FMPC Bldg. #64, 65, 67, & 68
PROJECT/PROGRAM TITLE	Repackaging, Overpacking and Shipping FMPC Inventoried Thorium Materials to NTS.
PROJECT COST	
CONSTRUCTION START DATE	
PROJECT/PROGRAM NUMBER	
NEPA DOCUMENT NUMBER	
NEPA SUBMITTAL DATE	

PROJECT EXECUTIVE SUMMARY

The current FMPC inventory of thorium consists of approximately 1100 metric tons of various thorium materials. These materials are in various types of containers stored in and adjacent to four FMPC warehouse buildings and includes packaged thorium from the Plant 8 Silo and bin. The overall plan for the disposition of the thorium is that the materials will be inventoried, packaged (as required) and overpacked in containers meeting DOT shipping criteria and Nevada Test Site retrievable storage facility criteria. The thorium materials will be placed on trucks and shipped to NTS for retrievable storage. No significant adverse environmental impacts are anticipated as a result of the overpacking and shipping effort. The no action alternative and the alternatives of repackaging and overpacking the thorium materials but not shipping them to NTS, repackaging/overpacking and shipping by rail, and repackaging/overpacking and shipping to sites other than NTS are considered. These alternatives are considered less desirable than the proposed action.

PROJECT JUSTIFICATION

The repackaging, overpacking and shipping of the FMPC inventory of thorium materials is required due to the current condition of the existing FMPC warehouse facilities and the condition of the individual drums and containers in which the thorium materials are contained. The years of storage have caused deterioration of the drums and containers as well as the storage warehouses. The repackaging and/or overpacking of the containers is required to assure the continued safe containment and storage of the thorium materials. The shipping of the overpacked thorium materials to the NTS retrievable storage facility is required to assure the safe long-term storage of the thorium without future rehandling while minimizing the potential exposure to personnel and the environment.

EXISTING NEPA DOCUMENTATION/DATE SUBMITTED			
NONE	N.C.	ADM.	E.A.

THIS NEPA DOCUMENT			
N.C.	ADM.	E.A.	E.I.S.

DOE APPROVAL REQUESTED	COGNIZANT PROJECT ENGINEER/DATE
	SITE NEPA COORDINATOR/DATE
DOE/FMPC _____	SITE NEPA MANAGER/DATE
DOE/ORO _____	SITE DOE OFFICER/DATE
DOE/HQ _____	ADDITIONAL DOE APPROVAL(IF NEEDED) DATE

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1.0 PURPOSE AND NEED FOR ACTION

The Feed Materials Production Center (FMPC) is a U.S. Department of Energy (DOE) uranium metal production facility located on a 425-hectare site near Fernald, Ohio, about 33 kilometers northwest of downtown Cincinnati (Figures 1-1 and 1-2). Most of the site is located within Hamilton County although approximately 81 hectares are situated in Butler County. The villages of Fernald, New Baltimore, Ross, and Shandon are all located within a few kilometers of the plant.

Currently under management of the Westinghouse Materials Company of Ohio (WMCO), the FMPC has been in operation since the early 1950's. It consists of nine separate production plants and 47 support buildings and facilities, including radioactive waste treatment and storage facilities. The primary mission of the FMPC is the production of purified uranium metal and uranium compounds for use at other DOE defense facilities. A small amount of thorium processing has also been conducted at the FMPC.

Since about 1972, the FMPC has served as the DOE storage site for thorium. The current FMPC inventory of thorium materials consists of approximately 1100 metric tons of various thorium compounds. The Plant 8 silo and bin contain approximately 175 metric tons of bulk thorium oxide materials plus other inert materials. Removal of the bulk thorium material from both the silo and bin and repackaging within smaller containers for interim on site storage is planned and was discussed in an earlier environmental assessment (DOE 1987). The remainder of the thorium inventory is stored within various size containers in FMPC warehouse Buildings #64, 65, 67, and 68. A small number of drums are in outside storage adjacent to Building #65.

The thorium materials in storage in the FMPC warehouses are held within a variety of containers including 322, 208, and 114 liter drums, 19 and 4 liter size cans, (85, 55, 30, 5 ,1 gallons respectively) and boxes. The majority of the containers are currently in satisfactory condition, however, some of the containers are beginning to show environmental deterioration. The deterioration is a result of the number of years in storage and the condition of the storage facility.

The proposed disposition of the FMPC thorium inventory involves three separate thorium projects. These projects are the Environment, Health & Safety Improvements (EH&SI) Line Item Project, the Thorium Metal Overpacking Effort, and the Warehoused Thorium Repackaging/Overpacking Effort. As a result of these three projects, approximately 17,000 containers of thorium material will be repackaged and/or overpacked to meet retrievable storage criteria and Department of Transportation (DOT) shipping

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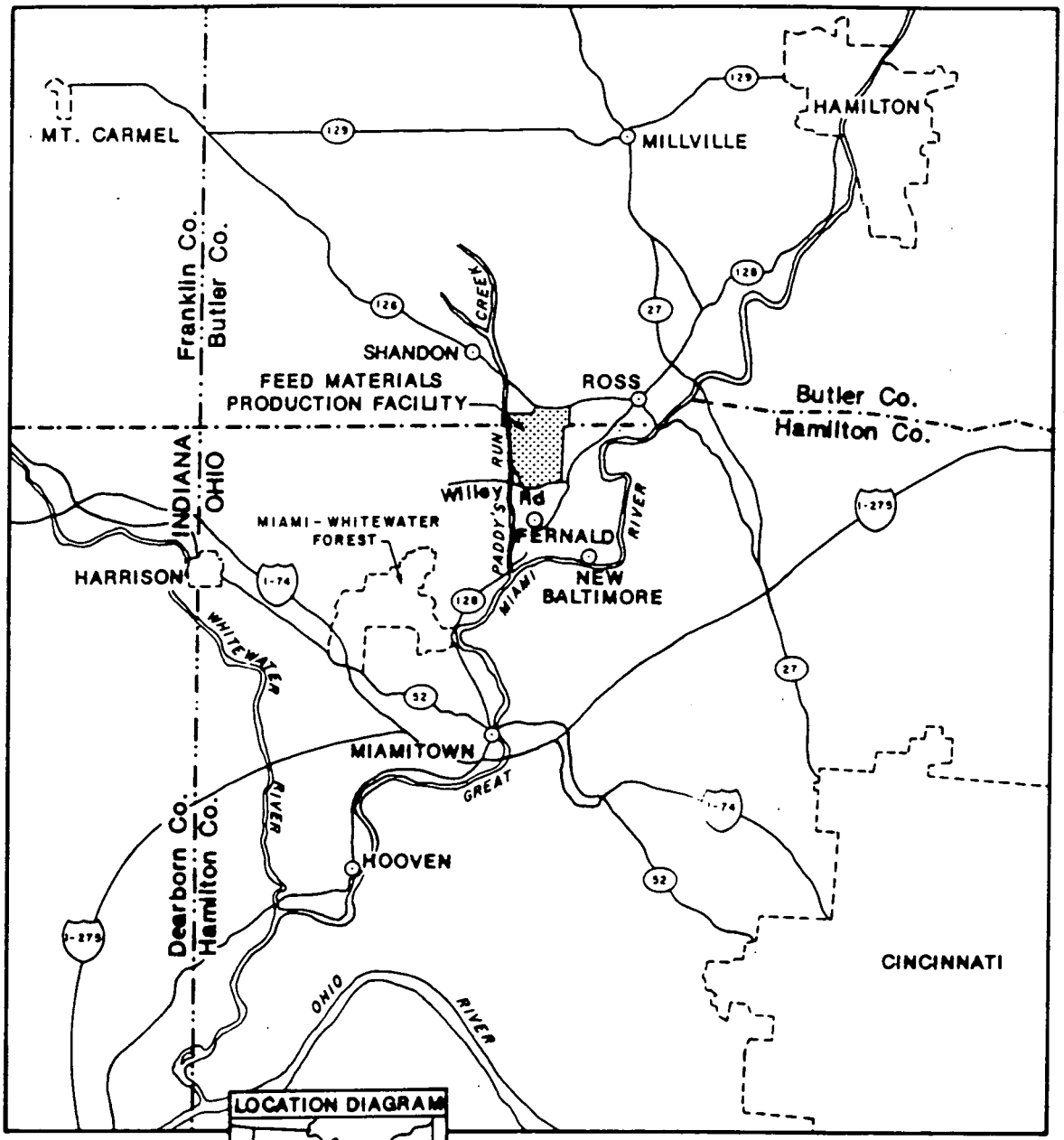

FIGURE 1-1

FEED MATERIALS PRODUCTION CENTER
REGIONAL AND LOCAL
LOCATON MAP

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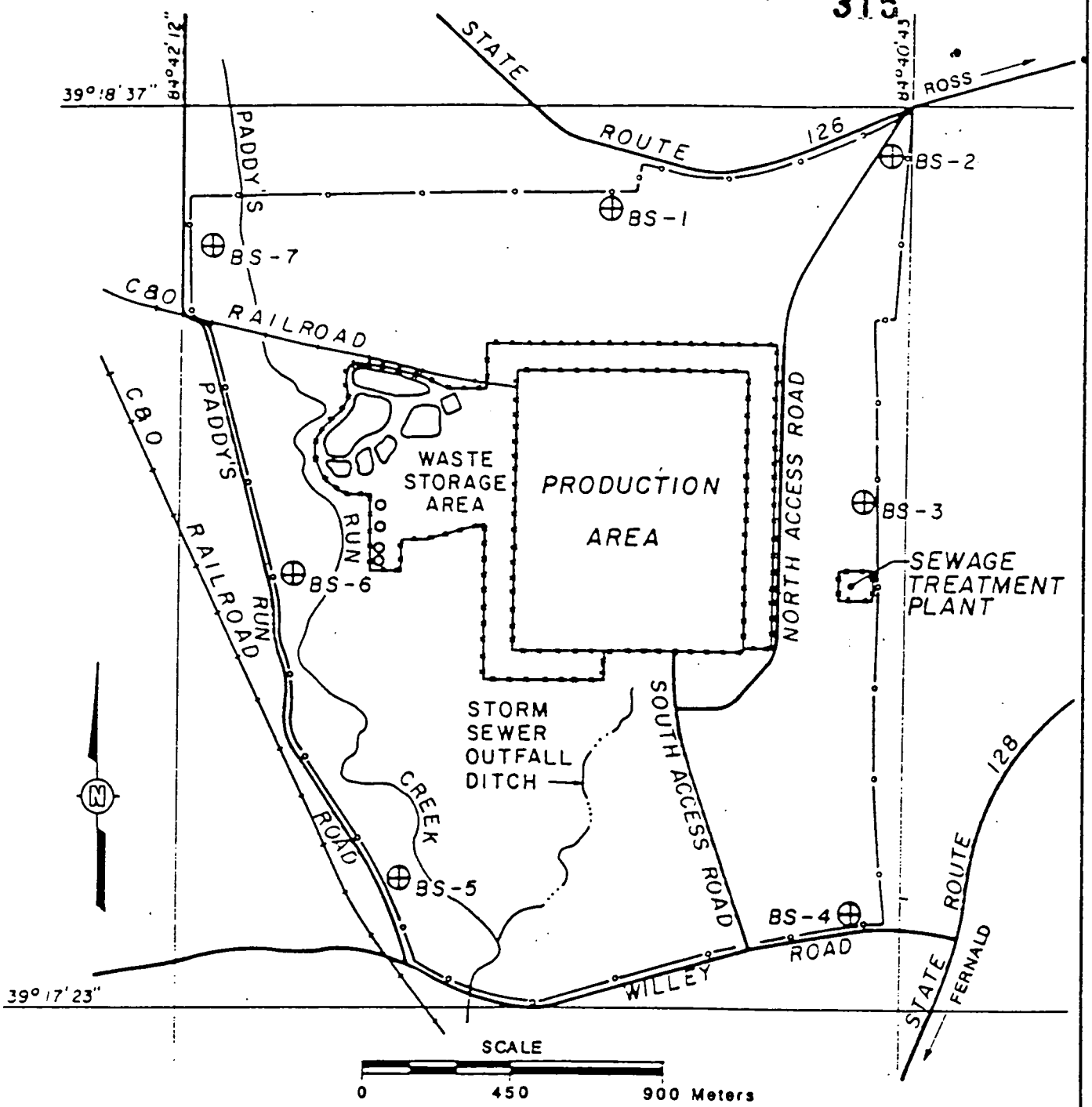
U.S. DEPARTMENT OF ENERGY



NOTE:
COORDINATES AT CENTER OF PRODUCTION AREA:
LONGITUDE 84° 41' 19", LATITUDE 39° 17' 58"

FIGURE 1-2

FEED MATERIALS PRODUCTION CENTER
DETAILED LOCATION MAP

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U.S. DEPARTMENT OF ENERGY

LEGEND

- SECURITY FENCE
- PROPERTY LINE FENCE
- GRID LINE
- BS-5 AIR QUALITY MONITOR SITES

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requirements and shipped to the Nevada Test Site (NTS) retrievable storage facility. This proposed repackaging, overpacking and shipment of the thorium materials is the subject of this environmental assessment.

The purpose of the proposed action is to stabilize deteriorating containers of thorium, and move the thorium from the FMPC site for long term retrievable storage under more appropriate conditions. This action is needed because the years of storage have caused deterioration of the drums and containers as well as the warehouses in which the material is stored. Shipping of the overpacked material to NTS is necessary to assure safe long term retrievable storage without the need for future rehandling. This will minimize potential exposure to personnel and the environment. Future handling will only occur at the time of retrieval.

2.0 DESCRIPTION OF THE PROPOSED ACTION

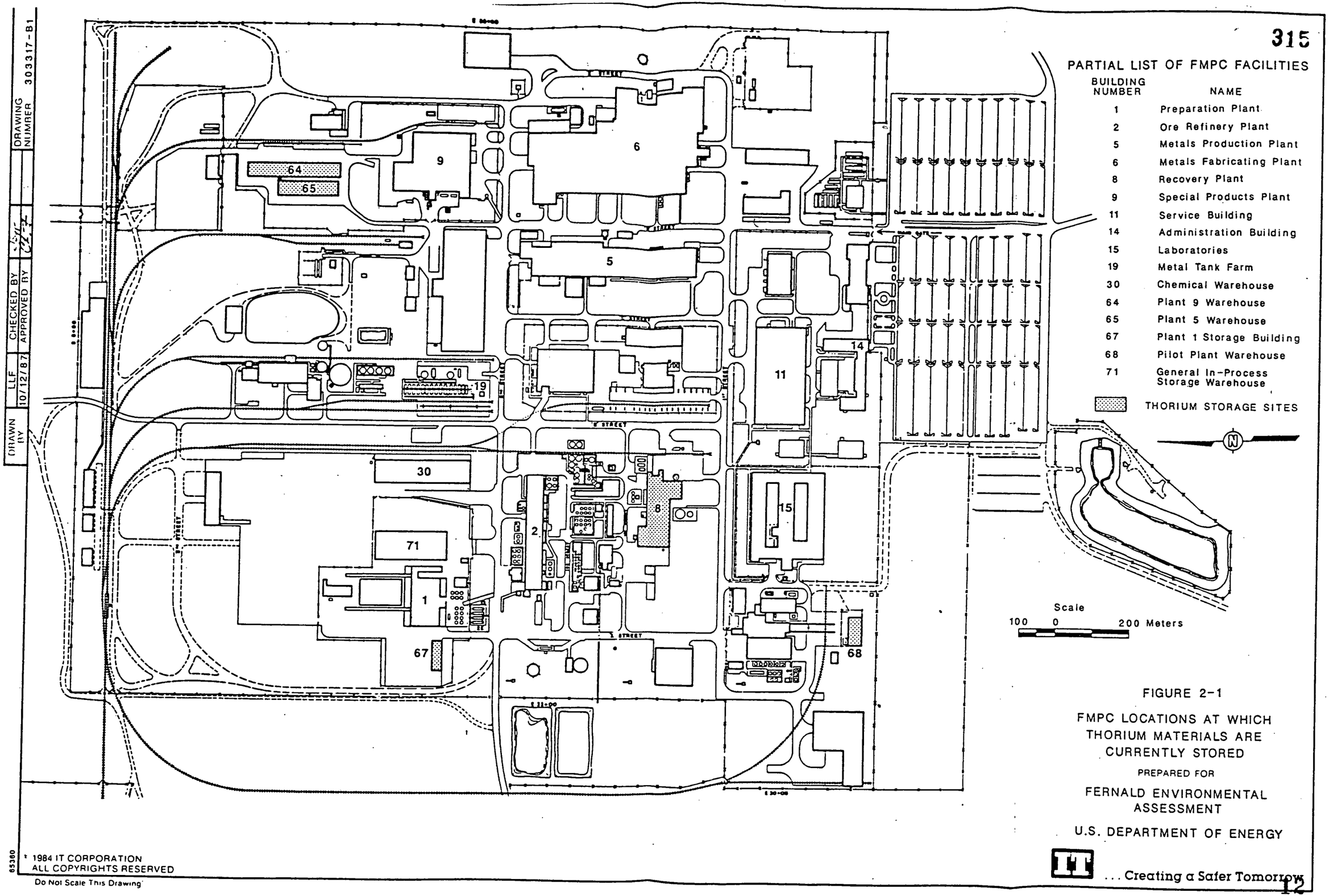
This section describes the history of use and storage of thorium materials at the FMPC, the proposed action and the alternatives to the proposed action. The section discusses the handling, repackaging and overpacking of the stored containers, the shipment of the thorium materials to the Nevada Test Site and the health, safety, and environmental quality control programs to be part of the proposed action.

2.1 INTRODUCTION

Beginning in the early 1970s, the DOE investigated using thorium materials as part of its efforts to develop economical methods of producing defense-related nuclear reactor fuel. The thorium materials have been stored since 1972 in a silo and a storage bin located at the FMPC "Plant 8", in containers in warehouse Buildings #64, 65, 67, and 68, and in 212 drums in outside storage adjacent to building #65 (Figure 2-1). The proposed action for this project is to repackage existing drums and other containers of nonpyrophoric thorium material, as necessary, and place them into shipping containers. Nonpyrophoric thorium material will then be transported by truck to the Nevada Test Site (NTS) for retrievable storage until a final decision on the disposition of the material is made. All thorium material shipped to NTS will be double contained either by placing a drum within a steel shipping container or by using a double walled shipping container. Pyrophoric thorium materials will be repackaged and held in storage at the FMPC until they have been treated and rendered nonpyrophoric.

Other alternatives considered include the following:

- Managing the thorium material as described above but transporting the material by rail, instead of by truck.
- Managing the thorium material as described above but transporting it to other DOE storage locations.
- Managing the thorium material as described above but holding the material in storage at the FMPC instead of transporting it to the NTS for storage.
- No action, an alternative which must be addressed in National Environmental Policy Act (NEPA) documentation.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PARTIAL LIST OF FMPC FACILITIES
BUILDING NUMBER
NAME
1 Preparation Plant
2 Ore Refinery Plant
5 Metals Production Plant
6 Metals Fabricating Plant
8 Recovery Plant
9 Special Products Plant
11 Service Building
14 Administration Building
15 Laboratories
19 Metal Tank Farm
30 Chemical Warehouse
64 Plant 9 Warehouse
65 Plant 5 Warehouse
67 Plant 1 Storage Building
68 Pilot Plant Warehouse
71 General In-Process Storage Warehouse
THORIUM STORAGE SITES
N
Scale
100 0 200 Meters
FIGURE 2-1
FMPC LOCATIONS AT WHICH THORIUM MATERIALS ARE CURRENTLY STORED
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2.2 PROPOSED ACTION

The proposed action consists of the following activities:

- Overpack and place into shipping containers 212 drums containing 241 smaller containers of thorium material currently stored outside of FMPC Building 65. Nineteen of these containers contain pyrophoric materials and will be temporarily stored at the FMPC until they are treated by controlled oxidation to render them nonpyrophoric. The drums containing nonpyrophoric material will be placed in shipping containers and transported by truck to the NTS, where they will be placed in retrievable storage until a final determination of the material disposition is made.

- Overpack, if necessary, and place into shipping containers more than 13,000 containers presently stored in FMPC warehouse buildings #64, 65, 67, and 68. Two of these containers hold pyrophoric materials and will be repackaged and held at the FMPC for treatment. The remainder of these containers will be transported by truck to the NTS for storage.

- An additional group of containers of thorium material will result from an on-going program to remove thorium material from the Plant 8 bin and silo. An estimated 175 metric tons of thorium material are currently in bin and silo storage; it is estimated that approximately 2500, 208 liter drums or 400 double walled boxes will be generated through this program. These containers will be placed in shipping containers, if necessary, and transported by truck to NTS for storage.

2.2.1 HANDLING AND REPACKAGING/OVERPACKING

2.2.1.1 Characterization, Repackaging, and Overpacking of the Drums Stored Outside Building 65

This project will provide for the inspection, reidentification and repackaging of thorium materials and pyrophoric thorium metal fines currently contained in 212, 114 liter and 208 liter steel drums presently stored west of Building 65. They are in a horizontal position, stacked in three rows, three or four tiers high, with five centimeter by ten centimeter wood spacers between the tiers. The 212 drums hold 241 containers consisting of 19 liter steel buckets or 114 liter steel drums. Seventeen of the containers hold pyrophoric thorium metal fines, and two contain pyrophoric thorium metal turnings. Twenty-five of the containers hold various nonmetallic thorium oxides and oxilates, and the other 197 hold thorium metal solids.

The overpacking will take place in the area north of Building 65 and in a portion of the northern section of Building 64. The identification and repackaging area will be assembled inside Building 64 directly east of the stack of thorium drums.

Approximately 77 square meters of space will be used inside Building 64 for the repackaging effort. Two existing double sliding doors on opposite sides of the building will allow the transport of the drums through the repacking area. The deteriorated concrete slab areas between the drum stack and Building 64 will be cleaned and repaired to provide a smooth path for the fork-lift transporting the drums and a surface that may be easily cleaned in case of a spill.

Each drum will be removed from the stack using a shielded fork-lift equipped with specialized drum handling tines and placed on the drum transporting cradle. The fork-lift will transport the drum in the cradle to the repackaging area located inside Building 64 and place it on a table.

The repackaging area will be located on the existing floor slab within the building. All work performed inside the area will be directed remotely by a operator located behind shielding. The operator will view operations through an observation window. A 322-liter overpack will be aligned with the 208-liter drum on the cradle. When correct alignment is achieved, a ram will move the drum into the overpack. The conveyer will move the drum into position for attachment and closure of the overpack lid. A beta and gamma radiation scan then will be performed on the overpacked drum to confirm identification.

Drums that contain nonpyrophoric materials will be closed with a standard gasketed drum lid using a remote drum-lidding fixture. These drums will be placed into a standard DOT approved rectangular steel box for shipping. Each shipping box will hold three 322-liter drums on a maximum payload of 2268 kilograms. The shipping container will be removed from the east door of the enclosure by a fork-lift, then after it is closed, it will be loaded onto a truck for shipment to NTS.

Drums which contain pyrophoric materials will be closed with a gasketed drum lid which has been modified with gauges to indicate pressure and percent oxygen percent level, and venting attachments. These drums will be purged with argon before being transported to temporary storage on site for future controlled oxidation to a nonpyrophoric state. No pyrophoric material will be shipped off site.

2.2.1.2 Inventorying and Overpacking Drums in Buildings 64,65,67, and 68

There are presently more than 13,000 containers of thorium and thorium compounds in storage in warehouse Buildings 64, 65, 67, and 68. Most of the containers are 208-liter drums. The proposed action includes repackaging (if necessary), and placing the drums in "six-pack" DOT approved steel shipping boxes or other shipping containers. Up to ten percent of these containers may require overpacking in 322 liter drums either because the original containers are small and of nonuniform sizes, or because the original containers have deteriorated. Drums containing the thorium materials will be identified and inventoried using the FMPC Lot Marking and Color Coding System. As drums are packed for shipping, inventory information will be transferred to the exterior surface of the shipping container.

Work will be conducted on a warehouse by warehouse basis beginning with the warehouse where drums are in the best condition. A temporary shelter will be erected outside each warehouse to protect equipment and workers from the elements. Paved surfaces will be repaired as necessary to provide a smooth surface for fork lift operation and spill containment. Each 208-liter drum will be removed from the stack by shielded fork-lift and moved outside the building where it will be weighed, scanned and swiped before it is placed in a steel box shipping container. The weighing and scan will confirm inventory information for that drum. Six drums will be placed in each box. The load limit for the shipping boxes is approximately 2268 kilograms. As each steel box is filled, the lid will be installed, the box will be banded, labeled, and loaded onto a shipping trailer.

Following the same procedures, drums in the remaining buildings will be identified and packed in steel box shipping containers, six drums per box. Any drums which are found to be damaged or to have deteriorated will be patched in place and then repackaged in a 322-liter overpack. The increased size of the overpack allows only three overpack containers to be placed in each shipping box. The 5,900 non-uniform containers in Building 68 have reportedly deteriorated and may require the use of additional robotic equipment in the repackaging process.

Building 67 holds thorium materials in 600 containers of non-uniform size. These may require overpacking before being placed in steel shipping boxes. Two containers of thorium metal chips and turnings are included in the inventory in Building 65. These materials may be pyrophoric in their present state and cannot be shipped to the NTS. Therefore, the two containers of thorium metal chips and turnings in this 600 drum lot will be marked and stored separately until an on site facility is available to oxidize the thorium materials. The pyrophoric thorium materials

will be overpacked in containers filled with an inert gas atmosphere and equipped with appropriate monitoring devices.

2.2.1.3 Silo and Bin Storage Thorium Material

The thorium materials currently stored in the Plant 8 silo and bin will be packaged in drums or in steel double walled boxes. The potential environmental impacts of this action are addressed in a separate document (U.S. DOE, 1987). The drums will be placed in shipping containers and loaded on a truck for shipment to NTS. If the steel double walled boxes are used, they will be loaded and shipped without further overpacking.

Shipments of thorium materials to NTS will be integrated into the scheduled shipments of processed FMPC low-level waste which are being sent to that site for disposal. This integration is required by the NTS to accommodate the need for a steady stream of material to that facility.

2.2.2 SHIPMENT OF THORIUM MATERIALS TO THE NTS

The total thorium inventory from the three thorium projects involves approximately 17,000 containers. Using the currently utilized six-pack steel shipping box as an example, this amount of thorium would require 2,500 shipping containers. Based on an anticipated typical shipment to NTS of eight shipping containers to a truck load, and five loads of thorium materials shipped per week, the work-off period required is approximately sixty-five weeks. This anticipated work-off schedule could change depending on the actual shipping containers selected for the thorium projects, as well as the actual amount of thorium materials contained in the Plant 8 silo and bin. Weather delays, contractor problems, document approval delays and FMPC plant shutdowns are not included in this schedule.

Shipping containers are designed to meet DOT standards, and will accommodate six 208-liter drums, or three 322-liter overpacks. The interior of the filled shipping container may be sprayed with a rigid non-organic foam material or the drums will be mechanically stabilized to control drum shifting. This will prevent structural damage and integrity while in transit. The thorium material to be shipped is defined by DOT (49 CFR 177) as low specific activity (LSA) material. The applicable NTS acceptance criteria are the same as for the low level uranium waste material shipments covered in a previous EA (DOE, 1985a).

The FMPC plans to engage the services of a commercial carrier for truck shipment of all wastes to the NTS. Radiation levels during transport will meet DOT regulations (49 CFR 173) for DOT "exclusive use" vehicles. Consistent with these same DOT regulations for highway transport (49 CFR 173), the shortest

route along the interstate highway system will probably be followed to minimize travel time and distance. The actual routing of shipments may vary, depending on weather and highway conditions. Local and state restrictions pertaining to hazardous material transport could also affect route selection, particularly in congested areas. It is the carrier's responsibility to select the appropriate route, and it is DOE policy that the carrier's route selection conform to applicable federal, state, and local regulations. Shipping containers will be loaded so as to prevent shifting and will be banded and shored as required.

2.2.3 HEALTH, SAFETY, AND ENVIRONMENTAL QUALITY CONTROL PROGRAMS

The health and safety and environmental quality control program to be developed for this project is common to the proposed action and the alternatives. The program is intended to meet DOE health and safety objectives and other regulatory requirements. Therefore, the program is not considered as additional "mitigation" measures for the purposes of this environmental assessment.

The no action alternative incurs different risks of environmental impacts and health and safety concerns than the other alternatives. The repackaging and identification activities result in short-term increased fire and spill risks. The no action alternative causes increased long-term fire and spill risks by allowing the drums to further deteriorate.

Engineering Controls

There is no HVAC system required for this project. All of the overpacking operations will occur outside or within an existing warehouse with an uncontrolled environment.

There are no additional piping requirements for the proposed action. There will be no plumbing or sewer system requirements for the project.

Power to operate needed equipment and lights for the proposed action will be supplied from the existing service available on site. A new service tap will be provided for equipment temporarily erected in Building 64 for the drum ram. Because of the short term operation of these facilities, no space capacity for future use will be included. As only one will be handled at a time, no provision will be made for simultaneous operation of all electrical equipment.

Fire protection will include the availability of portable Lith-X extinguishers for control of any fire involving thorium materials. All other materials will be noncombustible. All other fire detection and suppression equipment and activities will be in accordance with standard FMPC procedures and actions.

The FMPC site has a run-off and run-on control system, including a high density-polyethylene-lined lagoon system to control releases of contaminants to surface water. Any spills of thorium material will be managed according to the Spill Prevention, Control and Countermeasure (SPCC) Plan adopted for the FMPC. The plan specifically calls for covering or building a dike around all sewer or floor drains to preclude releases to run-off lagoons. These lagoons, in turn, provide for management of liquid effluent and precipitation run-off from the site.

Health Controls

The repackaging operation will be designed to minimize worker exposure to radiation. Routine monitoring will serve to identify sources of exposure and optimize the methods and procedures where necessary to assure that the exposures meet ALARA objectives. Written procedures describing the health physics program will satisfy the specific requirements of the proposed action as well as general DOE requirements (DOE, 1981). The repackaging area will be unoccupied except for an operator in a bubble suit with supplied air. The argon gas system used for filling overpacked pyrophoric drums will be equipped with quick connect/disconnect fittings, and will meet OSHA standards.

Operators and technicians will receive training on the methods to be used for the repackaging and overpacking. Mock-ups may be used for certain tasks to permit "hands-on" exercises to test the procedures. Other training courses will include specific methods to reduce individual exposure to radiation as well as fulfilling the site requirements for all workers.

External radiation exposure to repackaging personnel will be minimized by the use of temporary radiation shielding. Direct radiation levels will be monitored routinely using both portable instruments and passive dosimetry. Administrative controls will also be implemented to limit exposure to workers.

Exposure to airborne and surface contamination will be minimized by personal protective equipment including supplied air suit as required, routine monitoring, and operational procedures. Personnel exposure will be controlled to levels which meet DOE requirements or ALARA objectives. Air samples will be collected during repackaging operations to document that personnel exposures are acceptable. Radiological health and safety procedures which prohibit smoking, drinking, and eating on the

job will be enforced. The engineered and administrative controls are suitable to maintain personnel exposures to within radiation exposure limits for worker health protection.

Much of the proposed work involves worker hazards which are not unique to a facility handling radioactive materials. Health and safety concerns, besides radiation exposure, have also been considered and can be minimized. For this project, special emphasis will be placed on:

- Slips, trips, and falls
- Safe lifting techniques
- Heat stress.

Standards for minimum protection have been established by the Department of Energy (DOE, 1986) and by the Occupational Safety and Health Administration (29 CFR 1910). Compliance with these standards will be accomplished by implementing the health and safety program described in this section.

A safety and health plan will be prepared and approved by WMCO before the work begins. Written procedures describing the health physics program will satisfy the specific requirements of the proposed action as well as general DOE requirements (DOE, 1986). Work procedures will incorporate the safety measures that are necessary, such as:

- Hard hats for all persons
- Safety glasses and steel toe shoes
- Handtrucks to move drums and large boxes
- Fork-Lift or crane to move large items
- Procedures for handling hazardous radioactive or toxic materials.

All employees will participate in a site specific training program before work begins. The applicable mitigation measures will be discussed and demonstrated so that all employees have a clear understanding of means to prevent injury.

Nonradiological health and safety issues will be controlled in a safe and efficient manner. The training program will serve as the forum for identifying the necessary controls for this project.

2.3 ALTERNATIVES TO THE PROPOSED ACTION

In the process of determining the preferred alternative, other reasonable alternatives were examined. Alternative actions evaluated include:

- Managing the thorium material as described above with the exception of transporting the material by rail, instead of by truck
- Managing the thorium material as described above but transporting the material to other locations.
- Managing the thorium material as described above, but holding the material in storage at the FMPC instead of transporting it to the NTS for storage
- No action.

2.3.1 REPACKAGING/OVERPACKING THORIUM MATERIALS AND SHIPMENT TO THE NTS BY RAIL

In terms of on-site effort and planning, this alternative does not differ from the proposed action. However, implementation of this alternative may prove difficult due to rail carrier reluctance to transport radioactive materials. The nation's railroads have been engaged in litigation with industrial and governmental shippers of radioactive materials for more than 10 years in attempts to refuse to carry these materials, (DOE, 1984). The Interstate Commerce Commission has ruled against the carriers, and the federal courts have upheld the shippers. Nonetheless, to discourage rail shipment, the carriers often utilize higher freight rates for transport of radioactive waste materials, (YATES, 1985) and they also persist in demands for special trains. Further litigation is possible, although the railroads have apparently given up their alleged right of refusal to carry shipments of radioactive waste materials. Current DOE waste transportation policy is to accept any rail carrier's resistance to shipping radioactive material and to use the highway transport alternative (DOE, 1984). Further, the direct radiation levels associated with the thorium materials require that they be shipped by "DOE exclusive use" vehicles. This requirement further complicates the use of rail transport of the thorium materials. Because of these factors, shipment by rail is not currently an attractive alternative for transport of FMPC thorium materials.

Rail shipment of thorium materials to the NTS could be accomplished in one of two ways: (1) shipping containers could be placed directly aboard rail cars at the plant site and unloaded onto trucks at the rail debarkation point at Nellis Air Force Base for delivery to the site; or (2) shipping containers could be loaded into truck trailers as described for the proposed alternative, and the trailers could be loaded onto rail cars and unloaded at Nellis. The second procedure offers the advantage of reduced handling of the containers by rail carrier personnel at the origin and terminus of the shipment.

2.3.2 REPACKAGING/OVERPACKING THORIUM MATERIALS AND SHIPMENT TO STORAGE SITES OTHER THAN NTS.

A previous Environmental Assessment (EA) of several potential storage sites for low level radioactive waste has been prepared by the DOE (1985). This Assessment evaluated storage capability of the various sites and transportation systems to those sites. The conclusion of that Environmental Assessment resulted in the decision to dispose of all FMPC low level nuclear waste at the NTS. The evaluations, rational and conclusions of the low level nuclear waste EA are pertinent to the transport and storage of low specific activity thorium material as well. In addition the arid condition of the NTS are even more important to storage of the thorium material for possible future retrieval. Therefore further consideration of this alternative is not appropriate and it will not be addressed in this EA.

2.3.3 REPACKAGING/OVERPACKING THE THORIUM MATERIALS AND INTERIM STORAGE ON SITE

If this alternative is implemented, the steel shipping boxes will be placed in an on-site storage facility. The material will be maintained at FMPC until a decision is made about disposition of the thorium inventory. If the shipping boxes are stacked four high, an area of approximately 1,800 square meters would be required to store the estimated 2,500 containers expected to be required for the project. To protect the steel box containers from deterioration the storage area would have to be in a building.

2.3.4 NO ACTION

The "no action" alternative would maintain the status quo. Periodic inspections would be conducted to monitor the integrity of the storage containers. Inspections would be documented according to established procedures. In addition, radiation surveys would be performed regularly to determine any releases of thorium materials at each storage site. Routine maintenance would continue to be performed at each storage site. With the no action alternative, the potential for release of pyrophoric and nonpyrophoric thorium materials from deteriorating containers at the FMPC would increase.

3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 CLIMATE

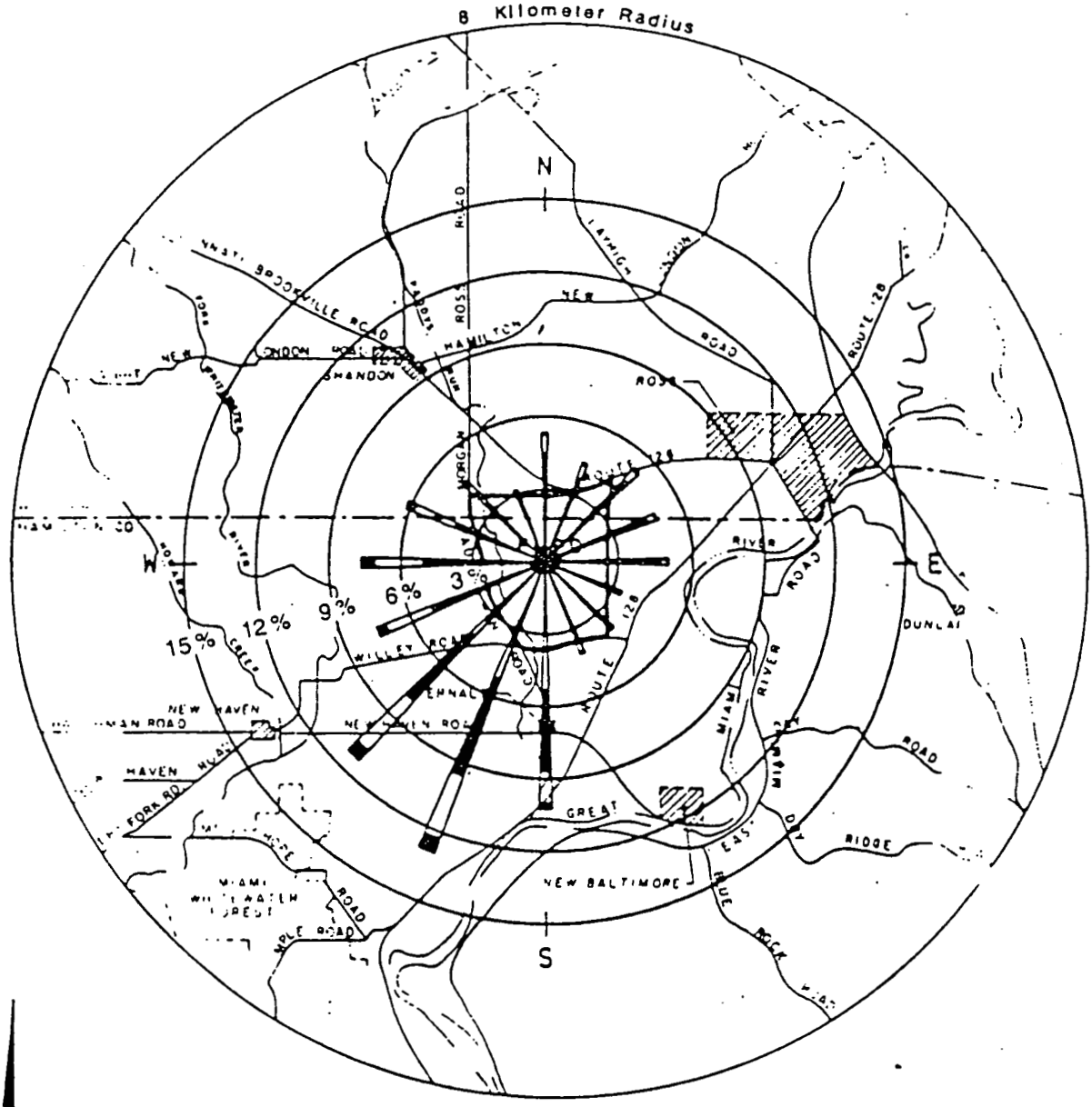
The FMPC area climate is basically continental with a wide range of temperatures. The area is subjected to frequent changes in the weather due to the passage of numerous cyclonic storms during winter and spring and the occurrence of thunderstorms during the summer.

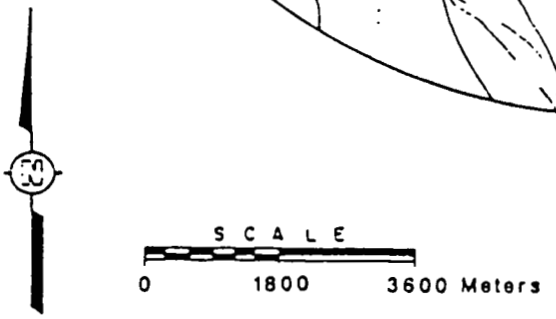
Mean annual precipitation is 102 centimeters which is, generally, distributed evenly throughout any 12-month period. Monthly maximums of approximately ten centimeters occur in May and July. Minimums of approximately six and one-third centimeters occur in February, October, and December. Over a 20-year period from 1960 to 1979, the average annual precipitation measured at the FMPC was 95.9 centimeters. Based on annual averaged data, the maximum recorded 24-hour storm event is 13.2 centimeters of precipitation. The heaviest precipitation, as well as the precipitation of the longest duration, is normally associated with low pressure disturbances moving in a general southwest to northeast direction through the Ohio valley south of the FMPC area.

Summers are warm and humid. The temperature may reach 40° Celsius or more one year out of three. However, the temperature usually reaches 26.7^{o} Celsius or higher about 117 days each year (based on a three year average 1983-1985). Winters are moderately cold with frequent periods of extensive cloudiness. The length of the freeze-free period is 190 days on the average. Freezing temperatures occur between late October and mid-April.

At the Greater Cincinnati International Airport, where climatic conditions closely approximate the FMPC site area, prevailing winds are from the south-southwest (toward the north-northeast) for all 12 months of the year. Average monthly wind speeds range from 10.8 kilometers per hour in August to 18.0 kilometers per hour in March. Channeling of airflow, and surface friction in the valleys reduce the wind speed and direct the airflow along the river valleys, such as along the Great Miami River. A windrose showing the wind direction frequencies and the average wind speeds for each direction is presented in Figure 3-1 (IT, 1986). [Meteorological data (DOE, 1985) used for dispersion modeling were provided by Oak Ridge National Laboratory and are summerized in Appendix A.]

The maximum wind velocity recorded at the airport was 64.4 kilometers per hour from the south-southwest. Wind records available for the FMPC show that there have been wind gusts in excess of 80.5 kilometers per hour on 11 occasions between 1960 and 1976; there have been gusts of up to 96.6 kilometers per hour on two occasions.





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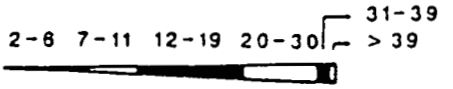

WIND SPEED CLASSES
Km/Hr

FIGURE 3-1

WINDROSE FOR GREATER
CINCINNATI INTERNATIONAL AIRPORT
(1958-1962, 1970-1974)
SUPERIMPOSED ON FMPC SITE

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Ohio lies on the eastern edge of the area of the U.S. with the maximum tornado frequency, the center line of which extends from northern Texas to south-western Iowa. During the 23-year period from 1953 to 1975, Ohio averaged about 13 tornadoes annually. During the 1900-1978 period, 15 tornadoes were observed in Hamilton County and 11 were seen in Butler County. Tornadoes may approach a location from any direction although about 90 percent come from the west through the southwest. Seventy percent of the tornadoes occur during April through July. The only tornado known to have touched the FMPC site occurred on May 10, 1969. There was no damage to the FMPC property, nor was there damage from another tornado which passed near the facility's northeast boundary on May 13, 1973.

3.2 AIR QUALITY

Air quality at and near the FMPC can be assessed for two regimes: (1) ambient air quality for the five criteria pollutants [sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), particulates, and ozone], and (2) ambient air quality for radionuclides and radon gas. Extensive air quality data have been collected at the site.

Of the criteria pollutants, atmospheric emissions of concern at the FMPC are particulates, SO_2 and NO_x. The performance of electrostatic precipitators at the FMPC boiler plant, the only existing stationary source, indicates the facility is in compliance with the Ohio Sulfur Oxide Standards (Ohio EPA, 1980). Coal having a sulfur content low enough to meet applicable stack emission standards for SO_2 is used in the boiler plant. The gaseous effluent of most concern is NO_x. Because there is no established federal or state limit for NO_x emissions, a clear stack criterion has been established as an objective for all production operations that generate NO_x.

The Hamilton County-Butler County area is an attainment area for all criteria pollutants except ozone and carbon monoxide. The ozone nonattainment status is due in large part to automobile emissions and, to a lesser extent, industry hydrocarbon emissions. An inspection and maintenance program is to begin in the near future. FMPC emissions do not contribute significantly to ozone ambient concentrations. The CO nonattainment status may be changed to attainment status in the near future following review of additional data by the Ohio EPA.

Ambient monitoring data for criteria pollutants in the FMPC area are extremely sparse. Review of Hamilton County-Southwest Ohio Air Pollution Control Area (APCA) data indicates there are no monitoring stations near Fernald in the general downwind direction (northeast of the plant). The closest monitoring station is at Miamisburg which is over 48 kilometers northeast of the site.

Conversion of impure uranium and thorium compounds to reactor-grade feed materials at the FMPC involves operations which generate radioactive particulates and reaction products in an air stream. Before release to the atmosphere, this air is filtered or scrubbed.

Air quality monitoring is conducted at seven FMPC boundary monitoring stations. The locations of these Boundary Stations (BS) are shown in Figure 1-2. Particulate samples are collected weekly for a 168-hour sampling period at an air flow rate of one cubic meter per minute on 20-by 25-centimeter microsorban filters. The filters are analyzed for gravimetric particulate loading, gross radioactivity, and specific radionuclides.

Five-year average concentrations (1981-1986) of particulate emissions, gross alpha radioactivity, and Th-232 are summarized in Table 3-1. Average gamma radiation levels at the site boundary are summarized in Table 3.2. These results indicate that releases at the FMPC site boundary are well within the "safe" levels established by regulatory agencies.

3.3 GEOLOGY AND SOILS

3.3.1 GEOLOGY

The FMPC site is situated within the Great Miami River Basin approximately 180 meters (580 feet) above sea level and 1.2 km (0.75 mile) west of the Great Miami River. The 425 hectare site is located on glacial deposits above the Great Miami River floodplain. The site is relatively level but slopes upward north of the production area to about 210 meters at the northern most edge of the site. Drainage across the site is from east to west to Paddy's Run dropping to an elevation of 170 meters. Paddy's Run flows from north to south through the western edge of the FMPC site and discharges into the Great Miami River (Figure 1-1).

The geology of much of southwestern Ohio consists of relatively flat Paleozoic sedimentary rocks overlain by Pleistocene glacial drift deposits. In the vicinity of the FMPC, bedrock consists of indurated shale interbedded with thin limestone units of late Ordivician age. The present landscape is characterized by broad flat plains, rolling surfaces along glacial moraines, and low rounded bedrock hills. The FMPC site is located on terminal and ground moraine deposits overlying outwash sands and gravels.

Prior to glaciation, this region of southwestern Ohio was drained by the Hamilton River System which was over 3.2 kilometers wide and dissected deep channels approximately 60 meters into the bedrock. These river channels have subsequently been filled by outwash from the receeding Illinoians and Wisconsin continental glaciers. The former Hamilton River Valley is now referred to as the Hamilton Trough.

TABLE 3-1

SAMPLING LOCATION	RADIONUCLIDE FIVE-YEAR AVERAGE CONCENTRATION (becquerel per cubic meter) GROSS a	Th^{232}	AIR PARTICULATE (Micrograms per cubic meter)
BS-1	2.2×10^{-4}	1.0×10^{-6}	36
BS-2	1.6×10^{-4}	8.1×10^{-7}	38
BS-3	2.5×10^{-4}	2.2×10^{-6}	37
BS-4	8.1×10^{-5}	8.5×10^{-7}	44
BS-5	1.4×10^{-4}	8.1×10^{-7}	43
BS-6	1.2×10^{-4}	6.3×10^{-7}	40
BS-7	6.3×10^{-5}	4.8×10^{-7}	38
Average Total	1.5×10^{-4}	9.7×10^{-7}	39
Standard Limit	7.4×10^{-2} (1)	3.7×10^{-2} (1)	75 (2)

(1) DOE Order 5480.1A, Attachment X1-1, Table II.
(2) State of Ohio Ambient Air Quality Standard.

From FMPC Environmental Monitoring Annual Reports, 1981-1985.

TABLE 3-2

AVERAGE GAMMA RADIATION LEVELS AT SITE BOUNDARY
uR/HR

	1981	1982	1983	1984	1985	FIVE-YEAR AVERAGES
BS1	10	10	11	9.7	10.8	10.3
BS2	12	12	12	10.3	11.5	11.6
BS3	12	12	12	10.3	11.1	11.5
BS4	11	11	11	9.7	11.1	10.8
BS5	11	12	12	10.5	11.1	11.3
BS6	18	19	18	15.5	17.0	17.5
BS7	12	12	13	11.4	12.4	12.2
Station Averages	12.3	12.5	12.7	11.1	12.1	12.2

The glacial outwash and till filled in the Hamilton River Valley, creating an extensive aquifer. The aquifier averages 3.2 km in width and 45 to 60 meters in depth near the FMPC. The trough is filled with basal deposits of glacial outwash, sand and gravel glacial outwash 30 to 55 meters in depth. A discontinuous 3 to 6 meter thick "blue clay" layer occurs within the sand and gravel aquifers discussed in Section 3.4.1. The sand and gravel is in turn covered with five to 15 meters of heterogeneous till.

3.2.2 SOILS

The primary soil units present at the FMPC are the Fincastle Silt Loam, Henshaw Silt Loam, Ragsdale Silty Clay Loam, Xenia Silt Loam, Martinsville Silt Loam, Hennepin Silt Loam, and Genesee Loam. The Fincastle, Henshaw, and Ragsdale soils cover the majority of the site. These soils occur on relatively flat Wisconsin till plain surfaces and are composed of silty loam at the surface. The soils are poorly drained and are characterized by low permeability and seasonal wetness.

The Xenia and Martinsville soils occur in the southeastern portion of the FMPC. Xenia soils also occur along the north boundary. These soils are silt loams which are moderately well drained and have moderate permeability.

Hennepin and Genesee soils occur along Paddy's Run in the western portion of the site. Genesee soils consist of loam and sandy loam and occur in valley floors. Hennepin soils consist of silty loam and occupy slopes along margins of drainages. (Lerch, N.K. et. al. 1980 and 1982)

3.4 HYDROLOGY AND WATER QUALITY

3.4.1 Ground Water Hydrology and Water Quality

Through the use of test borings for foundation design, well drilling, and waste pit evacuation at the FMPC site, many localized and shallow aquifers have been shown to exist in the glacial till deposits at the site (DOE,1985). These aquifers result primarily from infiltration of precipitation that becomes trapped in sand lenses in the clay till material. Studies of the geology and groundwater hydrology of the FMPC (DOE, 1985, 1981; Dames and Moore, 1985a, 1985b; and IT, 1986) have identified the existence of three principal aquifers:

1) a surficial till (or perched) aquifer
2) a shallow sand and gravel aquifer
3) a deep sand and gravel aquifer.

The discontinuous three to six meter thick "blue clay" layer, noted in section 3.3.1., separates the two sand and gravel aquifers while saturated lenses of sand and gravel characterize the surficial clay rich till layer. This results in the formation of perched zones that occur from 1.2 to 2.7 meters below the ground surface. Most likely, these zones are laterally discontinuous, therefore it is improbable that there is a direct pathway for re-charge to the two lower aquifers (DOE, 1987).

Of the three principal aquifers at the site, the two main aquifers are referred to as the shallow and deep sand and gravel aquifers. The shallow aquifer is approximately 23 meters thick and occurs below the clay-rich till layer. The deep aquifer, approximately 17 meters thick, occurs about 43 meters below the surface and is separated from the shallow aquifer by a 3 to 6 meter layer of the discontinuous "blue clay."

The shallow sand and gravel aquifer is unconfined with depth to water being approximately 17 meters below the surface. The deep aquifer is classified as a semi-confined or leaky confined aquifer due to the presence of the semi-pervious "blue clay" layer. Transmissivity of the shallow and deep sand and gravel aquifers is reported to range from 5.0×10^{-3} to 4.3×10^{-2} square meters per second (m^2/s). Hydraulic conductivity for these two aquifers is reported to range from 80-110 meters per day. Total porosity has been estimated at 25-35 percent (Dames and Moore, 1985a, as cited in DOE 1987).

These two sand and gravel aquifers are a major groundwater resource throughout the area. Recharge does not seem to be significantly affected by local precipitation, therefore these two aquifers are thought to be recharged over a large area.

Groundwater flow in the area between Paddy's Run and New Baltimore is generally from the north to south-southwest, under the FMPC, toward the Great Miami River. Groundwater pumping by the FMPC and by other industrial facilities east of the site may affect the direction of groundwater movement within the area. FMPC wells withdraw an average of 1,325 cubic meters of water a day (DOE, 1987) with additional usage to the east by Southwestern Ohio Water Company. The Cincinnati Bolton Plant, and the Southwestern Butler County Water Association (DOE, 1987) are within 5.6 miles east-northeast, and northeast of the FMPC respectively. Cumulatively, the three water companies withdraw approximately 125,000 cubic meters of water per day from the glacial aquifer in the Hamilton Trough.

As part of on-going environmental characterization programs at the FMPC, samples of groundwater have been collected for chemical analyses from both the FMPC and the surrounding area. This program includes sampling and analyses of samples from 15 on-site

wells and 22 off-site wells. Sampling of on-site wells is conducted to monitor the quality of groundwater at the site in conjunction with Resource Conservation and Recovery Act (RCRA) groundwater monitoring requirements. Recent sampling results of the groundwater quality underlying and in the vicinity of the FMPC can be found in DOE, 1986a.

3.4.2 Surface Water Hydrology and Water Quality

Drainage from the FMPC Site flows into Paddy's Run, an intermittent stream which flows southward along the western edge of the site and discharges about 3.2 km (2 miles) down-stream into the Great Miami River (Figure 1-1). FMPC waste storage areas are located east of and adjacent to Paddy's Run. It is possible that some seepage could contaminate this creek (DOE, 1985). South of the production area site a storm sewer outfall ditch flows to Paddy's Run (Figure 1-2). Overflow from the storm sewer collection system is routed to Paddy's Run via the storm sewer outfall ditch. Paddy's Run intersects the sand and gravel aquifer between Willey and New Haven Roads. The location where Paddy's Run intersects the water table and becomes perennial varies seasonally.

Treated liquid waste, sewage, and storm water flows through an underground pipe from the FMPC into the Great Miami River. Discharge is in compliance with a National Pollution Discharge Elimination System (NPDES) permit.

Surface water samples from both the FMPC site and surrounding areas have been collected for chemical characterization. These analyses indicate that the storm sewer outfall ditch is the main contributor of uranium-bearing water to the shallow aquifer (Dames and Moore, 1985a). An additional contributor of uranium-contaminated water may also be water flowing into Paddy's Run from the Waste Storage Area (Figure 1.2) of the FMPC (Dames and Moore, 1985a). Infiltration of surface water at the FMPC into the sand and gravel aquifers is minimized by the presence of the clay-rich till.

3.5 BIOLOGICAL RESOURCES, VEGETATION, WILDLIFE, AND AQUATIC ECOSYSTEMS

This section provides a description of vegetation, wildlife, and aquatic ecosystems on the FMPC site and in the general vicinity of the FMPC. A discussion of rare, threatened, or endangered species is also provided. Detailed information on FMPC site ecology is available in a two-volume report, "Biological and Ecological Site Characterization of the Feed Materials Production Center," prepared by Miami University of Ohio.

3.5.1 VEGETATION

The communities occurring on the FMPC are elements of a regional vegetation mosaic of woodland, agricultural land (pasture or crops), and developed land typical of southwestern Ohio.

Vegetation of the 425 hectare FMPC site includes a variety of vegetation types including old field, pasture, regularly mown grass area, planted conifer trees, native woodland areas, and developed land (Figure 3-2).

Old field vegetation is characterized by the presence of grasses (timothy [Phleum pratense], red top [Agrostis sp], Kentucky bluegrass [Poa pratensis]) and early successional herbaceous species (teasel [Dipsacus sylvestris], ragweed [Ambrosia sp.], moth mullein [Verbascum blatteria], wild parsnip [Pastineca sativa]).

Approximately 200 hectares of the FMPC is currently or was recently used as pasture for dairy cattle. This vegetation is dominated by red fescue (Festuca rubra) and other grasses such as timothy and Kentucky bluegrass. An area of mown grass occurs immediately around the plant site with an isolated patch maintained between the woodland adjacent to Paddy's Run and the planted conifer trees. The conifer trees were planted in 1972 and included white pine (Pinus strobus) and austrian pine (Pinus nigra). The planted conifer tree areas are adjacent to the FMPC production area near its southwestern and northeastern corners (Figure 3-2).

Total woodland (planted and native) area occupies 162 hectares on the FMPC Site. The native woodland vegetation is in various successional stages as related to the severity and frequency of disturbance in these areas. Disturbance to the understory is caused by cattle grazing and "bush-hogging." This affects the extent of native forest species regeneration which in turn affects the composition and structure of the woodlands.

The youngest woodland is comprised of species characteristic of the mixed floodplain forest community type following criteria set by Anderson (1986). This woodland is dominated by shellbark hickory (Carya lasciniosa), white ash (Fraxinus americana) with other common species present, such as hackberry (Celtis occidentalis), wild black cherry (Prunus serotina), boxelder (Acer negundo) American elm (Ulmus americana), and black locust (Robinia pseudoacacia) and shingle oak (Quercus imbricaria). Removal or alteration of the understory affects species composition such that more characteristic co-dominants (such as oak and walnut) may not be represented. The dbh (diameter at breast height) of this woodland type typically ranges from less than 2.5 cm dbh to approximately 35 cm.

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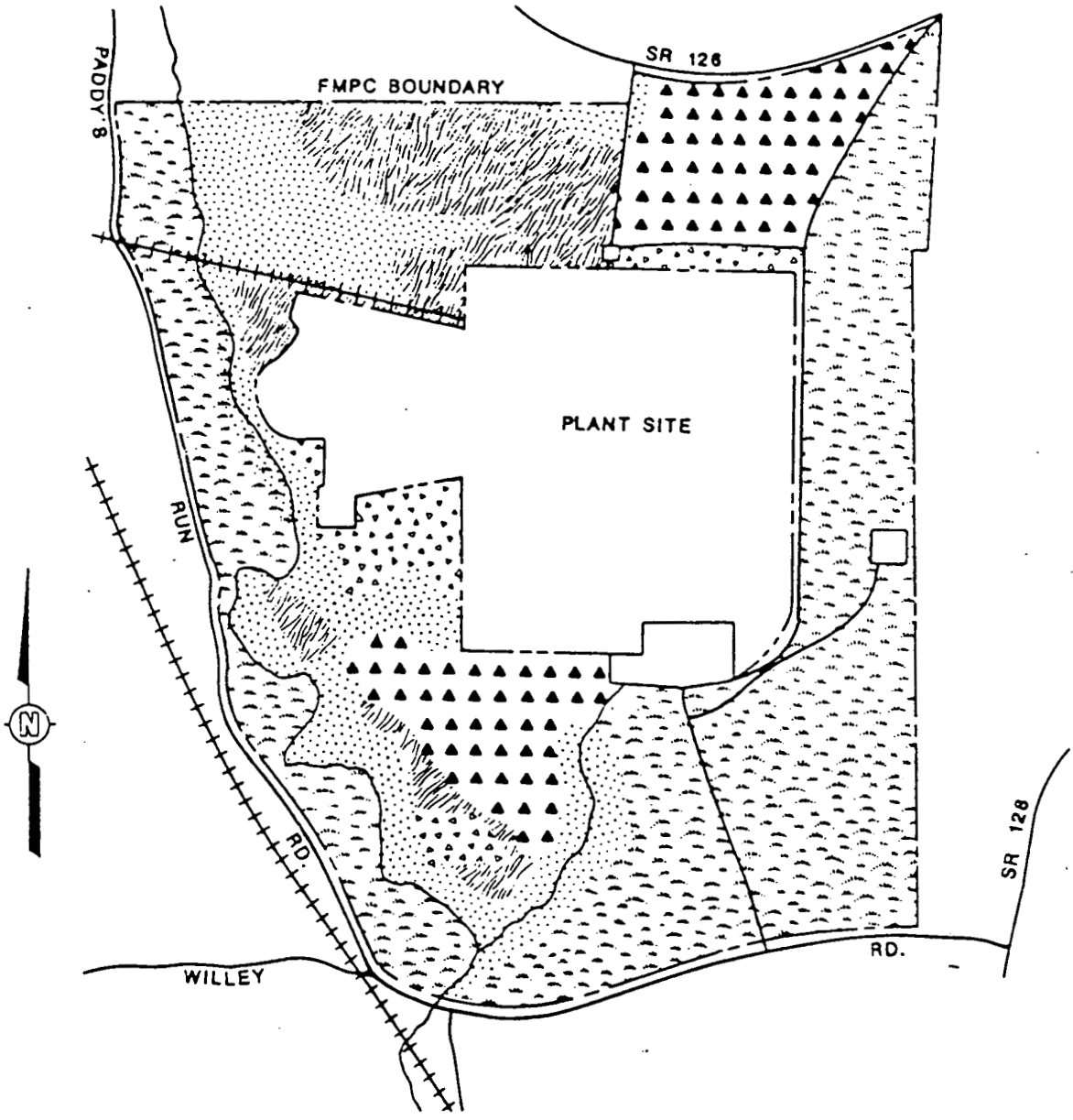

LEGEND

- PASTURE
- MOWED GRASS
- PLANTED CONIFER TREES
- WOODLANDS
- OLD FIELD

FIGURE 3-2

VEGETATION TYPES
OCCURRING AT FMPC PLANT SITE

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A more mature woodland, also characteristic of the mixed floodplain community type, occurs on site with sugar maple (Acer saccharum) as the dominant species co-occurring with boxelder, black walnut (Juglans nigra), Ohio buckeye (Aesculus glabra) and american elm. The subcanopy is dominated by sapling sugar maple and Ohio buckeye. The dbh in this woodland vegetation type ranges from 20-40 cm.

A riparian woodland borders Paddy's Run. Based on the dominant species represented, it is similar in character to a maple-cottonwood-sycamore floodplain forest. Dominant species are eastern cottonwood (Populus deltoides), hackberry, American elm and boxelder. Other common tree species present; are black walnut, Ohio buckeye, and sycamore (Platanus occidentalis). The shrublayer includes boxelder, hackberry, poison ivy (Rhus radicans) and trumpet creeper (Campsis radicans). Two herbaceous species present are red fescue and goldenrod (Solidago sp.).

Anderson (1986), states that riparian woodland and vegetation is a fairly distinctive community-type characterized by having small amounts (under 20% of the canopy trees) of more mesic species (e.g. sugar maple, beech, red oak, white oak, etc.). This vegetation type often occurs along rivers and streams and is separated by the river channel and confined to the stream borders, with a drier forest type adjacent on terraces and slopes. Riparian woodland along Paddy's Run is a restricted narrow band of vegetation.

Developed land on the FMPC Property occupies approximately 63 hectares and little vegetation exists in this portion of the site.

Agricultural land in the vicinity of the FMPC is in pasture or crops. Crops include soybeans, corn, wheat, other vegetables and grasses for harvest as hay. Pasture vegetation is dominated by grasses and ruderal herbs. Fence rows and associated vegetation provides boundaries for many of the agricultural fields in the region. Developed land in the vicinity of the FMPC is primarily residential and typically consists of maintained lawn and planted horticultural and ornamental species.

3.5.2 WILDLIFE

Wildlife populations at the FMPC and surrounding area are typical of those in southwestern Ohio supported by a mixture of agricultural, forested, and developed land. This type of landscape creates large amounts of "edge" and "corridor" habitat which is beneficial to wildlife.

The woodland plots and corridors in the region support the highest diversity of wildlife. These areas provide cover and denning areas for species which often range into other habitats during foraging activities. Eighty three bird species have been observed on or closely adjacent to the FMPC by Miami University researchers (Osborne, et al., 1987). Common species occurring in all habitats include: mourning dove (Zenoida macroura), northern bobwhite (Colinus virginianus), american crow (Corvus brachyrynchos), common grackle (Quiscalus quiscala), american goldfinch (Carduelis tristis), bluejay (Cyanocitta cristata), and robin (Turdus migratorious).

The greatest number of species occurred in the woodland areas. The most common summer residents observed (Osborne et al., 1987) are yellow-billed cuckoo (Coccyzus americanus), bluejay, Carolina chickadee (Parus carolinensis), and American robin. Additional common summer residents include the downy woodpecker (Picoides pubescens), northern flicker (Colaptes auratue), eastern wood pee wee (Contopus virens), grey catbird (Dumetella carolinensis), European starling (Sturnus vulgaris), and the northern cardinal (Cardinalis cardinalis) among others (Osborne et. al. 1987). The most common winter residents include Carolina chickadee, dark-eyed junco (Junco hyemalis), American goldfinch, northern cardinal, and song sparrow (Melospiza melodia). Two species of owls have been observed wintering on site: the eastern screech owl (Otus asio) and the great horned owl (Bubo virginianus).

The most common avian species in the agricultural old field and pasture vegetation at the FMPC during the summer months are eastern meadowlark (Sternella magna), red-winged blackbird (Agelaius phoeniceus), and European starling (Sturnus vulgaris). In addition, the Savannah sparrow (Passerculus sandwichensis) has been observed utilizing the site for breeding. This is unusual because the Savannah sparrow does not normally breed in southwestern Ohio. Birds characteristic of the developed or residential areas include the starling, house sparrow, common grackle, mourning dove, and American robin. These species utilize developed sites in the area as feeding and nesting areas. Raptor species observed (Osborne et. al., 1987) on the FMPC property include the Cooper's hawk (Accipiter cooperii), red-shouldered hawk (Buteo lineatus), american kestral (Falco sparverius), and northern harrier (Circus cyaneus), in addition to the owl species noted above. A more detailed discussion of avifauna present on and adjacent to the FMPC is presented in the Biological and Ecological Site Characterization of the FMPC (Osborne et. al., 1987).

The most common species of native mammals at the FMPC site and vicinity are white-tailed deer (Odocoileus virginianus), eastern cottontail (Sylvilagus floridanus), fox squirrel (Sciurus niger), white-footed mouse (Peromyscus leucopus noveboracensis), eastern

chipmunk (Tamius striatus), woodchuck (Marmota monax), and raccoon (Procyon lotor). The most abundant small mammal in the woodland areas on site is the white-footed mouse. The short tailed shrew (Blerina brericauda), meadow vole (Microtus pennsylvanicus), and meadow jumping mouse (Zapus hudsonius) were noted in two riparian areas. The house mouse (Mus musculus), whose range encompasses the entire region, was not encountered on site during the Miami University investigations. The white-tailed deer population, which is concentrated in the onsite pine plantations, has an estimated herd size of 16 to 18 individuals. This is typical of this region of Ohio.

Developed land within the FMPC and surrounding area has limited use for wildlife. Certain mammalian species, such as opossum and raccoon, use available habitat in developed areas. Agricultural land and old fields can provide habitats for such animals as the raccoon, woodchuck, and white-tailed deer. These species use these areas of the FMPC to forage and browse.

3.5.3 AQUATIC BIOLOGY

The aquatic environment of the FMPC is dominated by one intermittent, third order stream, Paddy's Run. Paddy's Run flows north to south along the FMPCs western boundary into the Great Miami River approximately 3.2 km south of the FMPC site. The northern section is steeply graded and characterized by relatively high stream velocities and a rock/cobble substrate. The southern stretch, a depositional area due to its low stream gradient, is periodically dry from July to October. Water quality in the stretch of the Great Miami River at its confluence with Paddy's Run is compromised by high nutrient and ammonia concentrations and low dissolved oxygen due to upstream municipal and industrial wastewater discharges.

Paddy's Run supports a relatively diverse and abundant fish population. Data on fish populations in off-site streams are limited, but these populations are expected to contain the same assemblage as Paddy's Run. A total of thirteen species of fish have been identified. This community is dominated by juvenile cyprinids and percids. The dominant species appear to be the creek chub (Semotilus atromaculatus) and the bluntnose minnow (Pimephales notatus).

The orangethroat darter (Etheostoma spectabile) has been identified as a dominant (Battelle, 1981), but according to Osborne (Miami University, 1987), this species was common in Paddy's Run but not dominant. Differences in species composition are probably attributable to differences in sampling intensity between the two studies. Other reportedly common species found include rosefin shiner (Notropis ardens), Johnny darter (Etheostoma nigrum), and fantail darter (Etheostoma flabellare).

The distribution of fish species in the stream depends upon the physical microhabitat heterogeneity of the stream, e.g., riffles or pools. White suckers (Catostomus commersoni), silverjay minnows (Ericymba buccata), rosefin shiners, and Johnny darters were rare or absent from riffle areas but common in pools, while the fantail darter was common only in riffles.

A total of forty-four taxa of benthic invertebrates have been identified as either existing in the stretch of Paddy's Run that flows through the FMPC site, immediately upstream (100 meters) or immediately downstream (100 meters). Four taxa were identified as being dominant in the fall/winter survey conducted during the Miami University study (Osborne et.al., 1987): midges (Chironomidae), riffle beetle (Stenelmis sp.), mayfly (Caenis sp.), and stonefly (Allocapnia sp.). Seven other taxa were also common throughout the stream: the mayfly (Stenonema bipunctatum), isopod (Lirceus fontinalis), caddisfly (Cheumatopsyche sp., Hydropsyche sp.), segmented worm (Ogligochaeta), stonefly (Nemouridae), blackfly (Simulium sp.).

Caddisflies (Trichoptera) the dominant taxa were present during the summer (Battelle, 1981). Caddisflies species of the genus Cheumatopsyche were the most dominant group while Hydropsyche sp. and Chimaera sp. were also common.

The types of species present, their abundance, and the species diversity of the benthos in Paddy's Run appears to be typical of streams in southwestern Ohio. Similar benthic invertebrate assemblages have been documented in other studies (Osborne et al., 1987). Differences in the number of taxa and the mean macro-invertebrate densities found along Paddy's Run appear to be attributable to natural variations in stream flow, although differences between the two studies may be due to seasonal variations and differences in sampling intensities.

3.5.4 THREATENED AND ENDANGERED SPECIES

No federally endangered plant or animal species are known to be present on the FMPC site, however, two records, both documented in 1960, exist on the location of the cave salamander (Eurycea lucifuga), a state listed endangered species. This species has been found approximately 3.7 killometers southeast of the FMPC site in an unnamed stream tributary on the north side of Day Road below the FMPC site (DNAP-ODNR, personal communication with staff, 1987).

Three species of birds that appear on the "Rare Species of Native Ohio Wild Animals" list (DNAP-ODNR 1982) have been observed on site. A red-shouldered hawk (Buteo lineatus) was observed flying over the site during the winter of 1986-87. This species is listed as an "uncommon breeder" in the midwestern region and as a

"threatened breeder" in Ohio. One sighting of a northern harrier (Circus cyaneus) over the site was made in June, 1986. This was the only observation made. It was presumed to be either a late migrating individual or an individual nesting off site. Cooper's hawks (Accipiter cooperii) were sighted on numerous occasions during the summer and winter of 1986 - 1987, possibly indicating that the Cooper's hawks may have been breeding on site or, using habitats within the boundaries of the FMPC. The Cooper's hawk is listed as an uncommon but regular breeder in the midwestern region, a "threatened breeder" in Ohio, and an uncommon to common fall migrant and winter resident.

3.6 LAND USE

The FMPC is located on a 425 ha site in a rural area of northwestern Hamilton County and southwestern Butler County, approximately 32 kilometers northwest of downtown Cincinnati (Figure 1-1). Approximately the northern 30 percent of the property, 81 ha is in Butler County (Figure 1-1). The production facilities occupy approximately 55 ha near the center of the site. The waste storage facilities are located on the site west of the production area.

The villages of Fernald, New Baltimore, Ross, and Shandon are all located within a few kilometers of the plant (Figure 1-1). Hamilton, Ohio (population 64,200) is approximately 16 km to the northeast.

The land surrounding the FMPC is primarily agricultural and is used for pasture and cultivated crops, with some light industry and scattered residences. Other local land uses include gravel quarrying operations along the Great Miami River, industrial facilities (e.g., Delta Steel and a phosphate plant), parks, and primary and secondary transportation corridors. Two commercial gravel extraction operations are located 1.6 kilometers east and 3.2 killometers southeast of the FMPC, respectively.

The nearest public park or resource area is the 823-hectare Miami Whitewater Forest located approximately eight kilometers southwest of the FMPC site in northwest Hamilton County (Figure 1-1). The Forest is one of the largest parks in Hamilton County. Approximately 20 percent of the 823 ha park is available or may be developed for public use (e.g., golfing, paddle boats. The remainder is dedicated as a wildlife sanctuary (Welsh, 1986). Other recreational areas near the plant site include: Fort Scott camps, 3.2 kilometers southeast of the FMPC, owned by the Archdiocese of Cincinnati, and Camp Ross Trails, a Girl Scouts of America camp located about 1.8 kilometers to the northeast.

Land use in Butler County is guided by the County Land Use Plan which was adopted in 1983-1984. Morgan Township, adjacent to the FMPC within Butler County, has zoning ordinances and relies on the County plan to control land uses. Ross Township (containing approximately 73 ha of the 425 ha) zones by class, i.e., residential and agricultural (Kosobut, 1986). The area north of the FMPC and south of State Route 126 is zoned for agricultural use (Thiem, 1986).

Hamilton County does not have a county plan; individual townships or municipalities may have their own zoning ordinances (Brienza, 1986). The majority of the FMPC is within Crosby Township which controls land use through zoning. Land immediately south of the FMPC is zoned industrial and to the east it is zoned agricultural. The FMPC existed prior to township zoning and is thus exempted from zoning ordinances (Strunk, 1986).

There are no hospitals or retirement homes within 8 kilometers of the FMPC, The closest facilities are located in the cities of Hamilton and Cincinnati which are 16 and 32 kilometers from the FMPC, respectively. The nearest schools are located in Ross and the Crosby Township School on New Haven Road, both approximately 3 km miles from the FMPC.

The Chesapeake and Ohio Railroad runs along the west boundary of the FMPC site. There are no other major transportation arteries in the immediate vicinity of the FMPC site. Interstates 275 and 74 traverse the area east to west about 8.8 kilometers south of the FMPC (Figure 1-1).

3.7 CULTURAL RESOURCES

The region encompassing the FMPC site has been extensively investigated for both historic and archaeological cultural resources. This has resulted in the identification of seven sites, currently placed on the National Register of Historic Places within an 8.0 kilometer radius of the FMPC: two archaeological districts (Hogan-Borger Mound archaeological district and Dunlap archaeological district), one historical district (Whitewater shaker settlement), two burial mounds or earthworks (Demoret mound and Ross Trails Adena Circle Mound), and two historic structures (Thomas Select School, John Vaughn House) (Pocket Figure 3.3). The archaeological sites are associated with the Late Archaic Period (ca. 4000 to 1500 B.C.) and the Early Woodland Period (ca. 1500 B.C. to A.D. 100). Whitewater Shaker Village, a local point of interest, is situated about eight kilometers west of the FMPC.

The Miami Purchase Association for Historic Preservation conducted a reconnaissance level survey of the New Haven Trough area in the Spring of 1985 (Genheimer and Gatus, 1986). This

investigation, which covered a 10,000,000 square meter area south and west of the FMPC, did not identify any sites eligible for inclusion on the National Register. However, Crosby Township has 240 surveyed historic properties including: Whitewater Shaker Village (10); New Haven (27); Fernald (11); and New Baltimore (11) (DOE,1987).

3.8 SOCIOECONOMIC CONDITIONS

Within 80 kilometers of the FMPC, There is a population of approximately 2,577,000. The 1984 estimated population for Hamilton County was 864,000; the estimated population for Butler County was about 275,458 NLO, 1985a. Hamilton County decreased by 1.1 percent from 1980 to 1984 while Butler County population increased by 2.6 percent during the same period.

Most populated areas in the vicinity of the FMPC have unincorporated small towns varying from an estimated population of 30 at Fernald to 3,000 at Ross. Fernald and New Baltimore in Hamilton County and Shandon and Ross in Butler County are the communities closest to the FMPC site.

The population of the seven small communities nearest the FMPC, and their approximate distances from the site, are as follows:

COMMUNITY	1980 ESTIMATED POPULATION	APPROXIMATE DISTANCE FROM FMPC (kilometers)
Fernald	50*	2.5
Shandon	200*	4
Ross	2,767	3.5
New Baltimore	710	4
New Haven	300*	5
Harrison	5,855	10.6
Miamitown	1,559	8.1

The FMPC employs 1,620 people. About 80 percent of this total work the 8:00 a.m. to 4:30 p.m. shift on weekdays. On weekends, this workforce population is reduced to about 175.

*These are rough estimates only because population data are available on a "neighborhood" basis. Fernald and New Haven are part of the West Crosby Township neighborhood with a 1980 population of 1,760.

3.9 TRANSPORTATION NETWORK

It will be the responsibility of the carrier to select the transportation route in conformance with applicable federal, state and local regulations. Consistent with DOT regulations for highway transport (49 CFR Part 177), it is expected that the shortest route along the interstate highway system will be followed to utilize interstate highways and minimize travel time and distance. The most probable route follows State Highway 128 south to Interstate 74, west to Interstate 465 bypass around Indianapolis and west on Interstate 70 to Utah, bypassing St. Louis, Kansas City and Denver. The final segment consists of Interstate 15 to Las Vegas, Nevada, and U.S. Highway 95 to the Nevada Test Site. The total route is 3,273 kilometers long and breaks down by the highway type as follows: interstates, 3,055 kilometers; U.S. highways, 179 kilometers; state highways, 29 kilometers; and local routes, 9.8 kilometers. The actual route of each shipment could vary with weather and highway conditions. State and local restrictions on hazardous material transport may also affect route selection, particularly in urban areas. The transportation network to be used traverses urban, suburban and argricultural areas as well as a variety of native vegetation systems such as eastern deciduous forest, plains grasslands, coniferous forest, Great Basin desert, and Mojave desert vegetation. A detailed description of the vegetation wildlife, geology, soils, hydrology and water quality, and cultural resources along the entire transportation network is beyond the scope of the EA.

3.10 RADIOLOGICAL CONDITIONS

The FMPC has been in operation since 1954. During this period raw materials, product and waste materials have been processed and stored on the site. Uranium processing operations at the FMPC site result in direct radiation levels which vary considerably on-site according to proximity to radioactive sources. Direct radiation levels are measured at the seven boundary air quality monitoring stations using thermoluminescent dosimeters (TLDS). Measured radiation levels are shown in Table 3-2. They range in the neighborhood of 10-20 micro roentgen per year.

The thorium materials are currently stored in containers in various stages of environmentally enduced deterioration. Background dose rates have been determined for the area(s) on-site where thorium repackaging will occur. The ALARA Evaluation of the Thorium Metal Barrel Repackaging Effort [WMCO:EH(HP):87:1004] uses 7 mrem/hour as the background dose rate when calculating rough dose estimates for personnel completing the overpacking operation.

4.0 ENVIRONMENTAL CONSEQUENCES

This section examines the potential environmental consequences associated with the proposed action and alternatives for the final disposition of 1100 metric tons of thorium materials currently stored at the FMPC. The assessment was accomplished by defining potential radiological and nonradiological releases and release pathways, calculating the resulting exposure or contaminant levels and assessing the resulting impacts to health, safety and the environment. Both routine operations and potential accidents were considered in the assessment of the proposed action and alternatives.

4.1 ASSESSMENT BASIS AND METHODOLOGY

4.1.1 Conceptual Approach

The assessment of impacts is based on a conceptual approach that provides a logical analysis structure. A major element of the approach is the determination of significance.

The consideration of impacts includes the determination of the significance of the impact(s) and the level of the effect the impact(s) have on the resource(s) affected. The determination of significance is complex. Evaluations of significance include an assessment of the intensity and extent of potential impacts. Intensity is based on the relative changes:

- To the unique characteristics of the area (visual quality, prime agricultural land, paleontological resources, archaeological sites, wetlands, ecologically critical areas, etc.)
- Likely to be controversial (examples of impacts considered to be controversial include those impacts for which there is a likelihood of a substantial dispute, those impacts about which segments of the public indicate substantial concern, or those impacts which have been found to be controversial on other projects)
- In cumulative impact
- Likely to adversely affect threatened, endangered, or otherwise unique species
- In public health and safety

- In resources considered to be important or valuable from the perspective of scientific opinion and management agency concerns
- Involving uncertain, unique, or unknown risks.

Extent is related to:

- The area/quantity of the resource affected relative to the area/quantity of the resource available
- The potential for change in reproductive success and maintenance of a population at pre-project levels
- The duration of time during which recovery will occur.

4.1.2 Source Term Development

In addition to the physical and operational descriptions provided in Sections 1.0 and 2.0, the impact assessment required that certain characteristics of the thorium material, current storage containers and handling methods be known or estimated. Based upon this information, releases during routine operation and where postulated, accident conditions were approximated. This source term development is described below for the proposed action and each alternative.

4.1.2.1 Proposed Action

The proposed action involves overpacking, shipping and placing in retrievable storage approximately 17,000 containers of thorium materials currently stored at various locations at the FMPC. As described below, these operational activities will potentially result in both radiological and nonradiological releases during routine operation and under postulated accident conditions.

4.1.2.1.1 Routine Operations

Routine operations involve container handling activities at the FMPC site, the transport of overpacked containers to the Nevada Test Site (NTS), and the placement of the thorium material into retrievable storage at NTS. Each of these project phases involve different modes of exposure and different populations and environments at risk. Potential impacts associated with the NTS site activities are addressed by the Final Environmental Impact Statement for NTS (ERDA, 1977) and are not assessed in this EA.

4.1.2.1.1.1 FMPC Site Activities

The proposed thorium handling and repackaging activities at the FMPC will result in direct (external) radiation exposure to workers as well as potential internal exposure to workers and members of the public through the release and inhalation of thorium particulates. External exposure to workers will be associated with handling activities. Ambient background dose rates adjacent to drum storage areas were measured at seven milliroentgens per hour ($7x10^{-2}$ millsieverts per hour) (Walker, 1987a). In another survey, dose rates at the surface of an array of drums were 70 milliroentgens (0.7 millsieverts per hour) on contact, decreasing linearly at a rate of 10 milliroentgens per hour per 0.3 meters (0.1 millsieverts per hour per 0.3 meters) (Walker, 1987b). These direct radiation levels were considered indicative of the dose rates associated with all containers of thorium material to be handled by workers during the proposed action. Because of the attentuation of gamma radiation in air, direct radiation exposure to off-site members of the public will not occur during routine operations.

Airborne contamination is expected to be generated during container handling, and packaging for shipping. The containers exhibit varying degrees of environmentally induced deterioration and it is likely that the surface of existing containers are contaminated. For the purpose of dose assessment for routine operations, it was assumed that existing surface contamination levels are at the Department of Transportation allowable shipping limit of 22 disintegrations per minute per square centimeter (0.37 becquerels per square centimeter) of Th-232 (40 CFR 173). All containers to be handled were conservatively assumed to be 208-liter drums characterized by DOT 17C specifications, each with a surface area of 21,700 cm^2. The thorium containers in the FMPC inventory are distrubuted as follows:

- 2% - 322 liter (85 gallon) drums
- 45% - 208 liter (55 gallon) drums
- 10% - 114 liter (35 gallon) drums
- 20% - 19 liter (5 gallon) cans
- 10% - 4 liter (1 gallon) cans
- 13% - boxes of various size

For the purpose of estimating a maximum routine thorium release, it was assumed that one percent of the surface contamination on all containers currently stored outdoors will become airborne during handling. The percent of surface contamination on containers stored inside buildings that will be released to the environment was limited to 0.5 percent to account for an assumed 50% plateout fraction on

surfaces within the buildings. All airborne contamination was assumed to be of respirable size, characterized by particles with an aerodynamic equivalent diameter of three microns. Based on these assumptions, it is estimated that 1.64×10^{-5} curies (4.07×10^{5} becquerels) of Th-232 will be released to the atmosphere over the course of the 65 week project.

During the completion of onsite activities nonradiological airborne pollutants will be emitted to the atmosphere from the operation of forklifts used to manipulate the thorium drums and overpacks. The combined pollutant emissions, over the life of the project, based on standard emission factors for this equipment type (EPA, 1984), assuming that forklifts will be liquid propane gas powered, are estimated as follows:

- 153 kilograms of carbon monoxide
- 30 kilograms of hydrocarbons
- 126 kilograms of nitrogen dioxide

4.1.2.1.1.2 Transportation to NTS

Transportation of thorium material by truck from the FMPC site to the NTS retrievable storage facility will result in some direct radiation exposure to the handlers, truck crew and population along the approximately 3273 kilometer route. External radiation levels for an array of drums have been measured in situ and provide a basis for estimating the radiation levels external to tractor-trailers to be used for shipment. Levels range from about 70 milliroentgens per hour (0.7 millisieverts per hour) at the surface to 10 milliroentgens per hour (0.1 millisieverts per hour) at 1.8 meters. The radiation field drops off at the rate of about 10 milliroentgens per hour per 0.3 meters (0.1 millisieverts per hour per 0.3 meters) (Walker, 1987b). All thorium will be packaged within shipping containers providing double containment to meet NTS acceptance criteria. The shipping containers will meet DOT requirements for shipment of Low Specific Activity (LSA) material, the classification applicable to the FMPC thorium material. The shipping containers will provide adequate containment for normal transport conditions and prevent members of the public from being exposed to airborne radioactive contamination. Eight of these shippinhg containers will be included in each shipment.

Based upon these package and shipment characteristics, a transportation index (TI) of 40 has been projected for each shipment (Walker, 1987b). The TI is defined as the dose rate in millirem per hour outside the transportation vehicle

at a distance of 0.914 meters. An estimated total of 325 shipments will be necessary to move the thorium material from the FMPC to NTS.

Although no routine release of radioactive materials will occur during the transportation phase, nonradiological airborne pollutants will be dispersed along the transportation route from the use of trucks for shipping. The combined pollutant emissions from all shipments, based upon standard emission factors for diesel tractor-trailers (EPA, 1984), are estimated as follows:

- 36,412 kilograms of carbon monoxide
- 3,932 kilograms of total hydrocarbons
- 3,478 kilograms of sulfur dioxide
- 26,593 kilograms of nitrogen dioxide
- 1,657 kilograms of particulates

4.1.2.1.2 Potential Accidents

This section assesses the environmental and health consequences of postulated accidents associated with the proposed action. A small probability exists that unplanned releases of thorium material may occur during the course of and handling operations on site, as well as during the transportation of shipping containers to NTS. For the purpose of evaluating the potential range of such events, credible accident scenarios were formulated and the resulting impacts evaluated.

Release Scenarios

Four accidents were postulated to provide a basis for assessing the potential magnitude of impacts that could occur during the proposed action. In all cases, the result is an unplanned airborne particulate release of Th-232 to the atmosphere. Considering the nature of the proposed action, such airborne releases are the most likely pathway of accidental exposure to the public. In addition, inhalation is the dominant mode of internal exposure for Th-232.

(1) Container Puncture

The first and most likely postulated accident involves a puncture by the forklift arms while moving the continers from storage cradles or platforms to the overpacking area. As a result of this accident, 10 percent of the thorium material stored in the container was assumed to be spilled. Considering packages that contain dispersable material, the average inventory per container was computed to be 158

kilograms of Th-232 with the maximum single container inventory of 420 kilograms Th-232 (Weinreich, 1987). The consequences of such an accident were evaluated by considering an initial release associated with the spill and a subsequent release due to resuspension of the spilled material. The initial release was modeled as a cloud having a volume of one cubic meter with an airborne thorium concentration of 100 milligrams per cubic meter which accounts for agglomeration and settling of particles (Elder et al., 1986). The resuspension phase of the accident assumes that 0.2 percent of the spilled material is resuspended by aerodynamic entrainment before the spill can be covered (Mishima et al., 1973). The resulting environmental release would be 32 grams or 3.5×10^{-6} Curies (1.3×10^{5} Becquerels) for an average inventory container. A puncture of the maximum inventory container would result in a release of 84 grams or 9.2×10^{-6} Curies (3.4×10^{5} Becquerels). The probability of such an accident is estimated to be once for every 2,000 containers handled or nine times throughout the life of the project. This relatively high incident rate accounts for the possible presence of punctures in containers from previous handling operations. Although procedures will be in place requiring the repair of such punctures prior to handling, the close spacing of containers in the stored inventory increases the liklihood that such damage will not be recognized before the container is moved. Assuming one puncture of the maximum inventory continer and eight punctures of average inventory containers, this type of accident results in a total environmental release of 3.7×10^{-5} Curies (1.4×10^{6} Becquerels) of Th-232 during the 65 week period of the project.

(2) Container Rupture

The second postulated accident involves a rupture of a container as a result of a container drop or failure during mechanical over-packing activity. The assumed release fraction from such a rupture is 25 percent. The same methodology used for a puncture was used to model the release due to rupture. The frequency for such an event is assumed to be once for every 4,500 drums or four times throughout the life of the project. Based on the average container inventory, the total release would be 8.6×10^{-6} Curies (3.2×10^{5} becquerels). The release for a single container with the maximum inventory kilograms would be 2.3×10^{-5} Curies (8.5×10^{5} becquerels). Assuming one spill involving the maximum inventory containers and three involving average inventory containers, this type of accident results in a total environmental release of 4.9×10^{-5} Curies (1.8×10^{6} becquerels) of Th-232 during the project.

(3) Fire

The third postulated accident involves a fire in one of the drums of finely divided thorium material stored outside of Building 65. It is postulated that an accidental breach exposes the pyrophoric material to the atmosphere resulting in a thorium fire. This accident is postulated to occur outside during handling activities. The fire is conservatively assumed to occur in the drum containing the highest inventory of pyrophoric thorium material, 100 kilograms. The estimated respirable release fraction during a fire involving nonvolatile solids is one percent (Elder et al., 1986). The thorium release in such an accident would be 1.1×10^{-4} Curies (4.0×10^{6} Becquerels).

(4) Transportation Accidents

A probability of an accident exists with the proposed truck transport of thorium material from the FMPC to NTS. The accident rate for trucks transporting radioactive materials is taken as 1.06×10^{-6} accidents per kilometer per shipment (NUREG-0170, 1977). For the estimated 325 shipments of thorium material to NTS, this corresponds to a total of 1.13 accidents over the 65-week shipping program. Based upon experience, less than one-half of such accidents will result in any release of radioactive material to the environment (NUREG-0170, 1977).

The amount of radioactive material released in the event of a truck accident is dependent upon several factors including the severity of the accident, the packaging of the material and its form. For the purpose of evaluating a worst-case accident scenario, it is assumed that the truck involved is transporting eight shipping containers of thorium oxide in granular form. Each container is assumed to contain a maximum 2500 kilogram loading of Th-232. Since the NTS acceptance criteria (DOE, 1985b) will be applied to FMPC thorium shipments, all material will be double contained providing at least three layers of containment when the trailer, itself is considered. For this scenario, it is assumed that 10 percent of the contents of a shipment could be spilled over 100 square meters of road surface. The resulting surface contamination level is 2.2×10^{-3} curies per square meter (8.1×10^{7} becquerels per square meter). The primary mode of radiation exposure to emergency response personnel and onlookers would be via inhalation of airborne thorium particulates. For the purpose of assessing this exposure, it is assumed that the spill remains uncovered for a one-hour period and that 0.2 percent of the spill, 0.44 millicuries (1.6×10^{7} becquerels), is resuspended by aerodynamic entrainment (Mishima et al., 1973).

4.1.2.2 Alternative 1 - Shipment by Rail

This alternative is identical to the proposed action with the exception that the thorium material would be shipped from the FMPC to NTS by rail. Routine and accident related releases identified for the proposed action as occurring at the FMPC site are equally applicable to this alternative. To assess the impacts associated with rail shipment it was assumed that semi-trailers would be piggy-backed on rail cars to facilitate the off-loading of the thorium material at Nellis Air Force Base. Trucks would then be used to transport the trailers the remaining 80 kilometers to the NTS retrievable storage area. On this basis, the TI for each trailer would be the same as for the proposed action.

Nonradiological airborne emissions will be dispersed along the transportation route taken to be 4000 kilometers for this alternative. Assuming that eight dedicated trains will be required, the combined pollutant emissions from all shipments, based upon standard emission factors for diesel locomotives (EPA, 1984), are estimated as follows:

- 7,178 kilograms of carbon monoxide
- 4,671 kilograms of total hydrocarbons
- 2,830 kilograms of sulfur dioxide
- 18,470 kilograms of nitrogen dioxide
- 1,245 kilograms of particulates

An accident during rail shipment of the thorium material is anticipated to result in a release similar to that of the proposed truck transport. Although significantly more thorium material would be associated with each rail shipment, the probability of a rail accident during the shipping program would be much smaller because of the fewer shipments required. In addition, limits on the allowable speed of a dedicated train and the lower average speed of rail transport in general would limit the severity of a potential accident.

4.1.2.3 Alternative 2 - Interim Storage On-site

This alternative involves the repackaging and/or overpacking of thorium material and interim storage at the FMPC. As such, routine and accident related releases identified for the proposed action to occur at the FMPC site are equally applicable to this alternative. No offsite transportation would occur.

4.1.2.4 Alternative 3 - No Action

This alternative would maintain the status quo. Containers of thorium compounds would continue to be stored both inside and outside of buildings at the FMPC representing a source of continuing direct radiation exposure to onsite workers.

Unlike the proposed action and other alternatives, the no action alternative prolongs and potentially increases the risk of a radiological release to the environment as a result of continued deterioration of containers or from a future natural event such as an earthquake. Routine annual thorium releases would be anticipated to increase with time, particularly for the drums of thorium stored outside. For the purpose of assessing the long range routine annual impacts of the no action alternative, it is assumed that as much as 0.4 percent of the thorium inventory stored outside could be lost on an annual average basis. This corresponds to a routine annual average release of 22 kilograms or 2.4×10^{-4} Curies (9×10^{5} becquerels) of Th-232 In addition, an accident scenario involving pyrophoric thorium fines is considered a possibility during the long-term.

The worst case accident for the no action alternative postulates the collapse of the storage array of drums outside of Building 65. The collapse is assumed to be induced by a seismic event with a breach of all drums containing pyrophoric thorium fines. The assumption of drum breach reflects the current deteriorated conditions of most drums at this storage location. Upon contact with air, the pyrophoric thorium is assumed to ignite with a subsequent airborne release of 1% of the inventory, 1.2 millicuries (4.4×10^{7} becquerels) of Th-232 (Elder et al, 1986).

4.1.3 Assessment Methodology and Results

This section describes the methodology used to perform dispersion and dose modeling for the source terms described in Section 4.1.2. Results of the modeling are provided for the proposed action and alternatives.

4.1.3.1 Non-radiological Releases

Section 4.1.2 identifies non-radiological emissions associated with the use of liquid propane gas and diesel-powered equipment. Based upon FMPC annual average meteorological conditions, maximum offsite concentrations of criteria pollutants associated with fork lift use were calculated. Resulting levels are compared to allowable limits in Table 4-1. Emissions resulting from truck or rail transport of FMPC thorium material to NTS will be dispersed along the transport network.

TABLE 4-1
MAXIMUM AIRBORNE CONCENTRATIONS OF NONRADIOLOGICAL EMISSIONS AT FMPC(1)

POLLUTANT	TOTAL ON-SITE RELEASE (KILOGRAMS)	AVERAGING PERIOD	CONCENTRATION (MICROGRAMS PER CUBIC METER)	NAAQS(2) (MICROGRAMS PER CUBIC METER)
Carbon Monoxide	153	8-hour	40	10,000
		1-hour	57	40,000
Nitrogen Dioxide	126	Annual	4.7	100

(1) Assumes that forklifts used for handling thorium materials will be propane-powered. Emissions apply to proposed action, rail alternative, and storage alternative.
(2) 40 CFR Part 50, National Ambient Air Quality Standards (Primary).

4.1.3.2 FMPC Site Radiological Releases

Potential releases of thorium associated with the proposed action and alternatives during routine operations and credible accidents were evaluated. Release source terms and pathways to the environment were based on conservative assumptions, or where available, on site-specific data. Accident assessments were based upon worst case conditions in the absence of known parameters. The dose assessment methodology and assumptions used to evaluate FMPC site releases are detailed in Appendix A and are summarized below.

4.1.3.2.1 Dose Assessment Methodology

From the description of the proposed action and alternatives presented in Section 2.0, airborne releases were identified as the principle environmental pathway of concern. Pathways to ground water, surface water, and soil were concluded to be inconsequential. The computer model AIRDOS.EPA, recommended by both the U.S. Environmental Protection Agency (EPA) and the DOE, was employed to calculate doses and evaluate resulting environmental consequences. This model utilizes meteorological data (taken from the Greater Cincinnati International Airport Weather Station), demographic data, release geometry, and local agricultural use data to project radiation doses to the human population within 80 kilometers of the site.

Dose assessment for routine operations was accomplished by applying annual average meteorological conditions to the postulated releases, then calculating the resulting air concentrations and surface contamination levels in all directions and at various distances from the FMPC site. The radiological exposure was then calculated by summing the exposures from all potential pathways. The modes of exposure from airborne releases that were considered in the dose-to-man calculations include the following pathways: (1) direct radiation due to immersion in air, (2) exposure to contaminated ground surfaces, (3) inhalation of contaminated air, (4) immersion in water through activities such as swimming, and (5) ingestion of contaminated drinking water and food grown on contaminated land. To assess the maximum exposure to a member of the public, a hypothetical individual was assumed to reside at the FMPC site boundary at the point where the maximum annual average concentration would occur for releases from thorium container handling activities. This location would not correspond to the point of maximum annual average concentration for FMPC site-wide releases identified in FMPC environmental monitoring annual reports.

Accident assessments were accomplished in a similar manner but stable meteorological conditions were assumed that allow little dispersion of a release, to maximize the resulting hypothetical dose to man. The wind direction was selected to correspond with the FMPC site boundary closest to any of the overpacking operations. The receptor for accident assessments was assumed to be a hypothetical member of the public who remained at that site boundary location and at the center line of the release plume for the duration of each postulated accident. No individuals reside any closer than 730 meters from the thorium storage location nearest the site boundary, Building 64 (ORNL, April, 1987).

4.1.3.2.2 Routine Operational Exposure Resulting From the Proposed Action

This section describes the radiological exposures to workers and the public. Both routine operations and potential accident conditions are considered.

Radiation Exposure to Workers

Radiation exposure to workers during routine operations will result from direct radiation and potentially from inhalation of thorium particulates. The thorium handling and repackaging activities will be covered in a radiological safety work plan. Administrative controls for occupational exposure include personal dosimetry, health physics surveys, radiation protection procedures, and use of protective clothing and respiratory protection, as required. These controls will limit radiation exposure to workers to as low as reasonably achievable within the DOE limit of five rem per year (5×10^{-2} sievert per year) (DOE, 1986).

Radiological Exposure to the Public

The radiological exposure to the public resulting from routine thorium handling operations was calculated using AIRDOS.EPA. Maximum annual air concentration and ground deposition for routine releases are outlined in Table 4-2. Approximately 99 percent of the potential exposure of humans to Th-232 results from the inhalation pathway. There are two radiation dose limits of interest in evaluating exposures to members of the public: (1) DOE guidelines of 100 millirem per year (1.0 millisievert per year), effective committed dose equivalent to any member of the public from all routine operations at the FMPC (DOE, 1987); and (2) EPA regulations for airborne emissions from DOE facilities of 75 millirem per year (0.75 millisievert per year) committed dose equivalent to the critical organ or 25 millirem per year (0.25 millisieverts per year) dose equivalent to the

TABLE 4-2
MAXIMUM AIR CONCENTRATION AND GROUND DEPOSITION OF
TH-232 RELEASED DURING ROUTINE OPERATIONS

DISTANCE (meters)	PEAK AIR CONCENTRATION (1) uCi/m^3 (3)	(Bq/m^3)	SURFACE DEPOSITION uCi/m^2	(Bq/m^2)
250 (2)	2.8×10^{-11}	(1.0×10^{-6})	2.9×10^{-6}	(1.1×10^{-1})
750	1.1×10^{-11}	(4.1×10^{-7})	1.1×10^{-6}	(4.1×10^{-2})
1,500	3.9×10^{-12}	(1.4×10^{-7})	4.3×10^{-7}	(1.6×10^{-2})
2,500	1.8×10^{-12}	(6.7×10^{-8})	2.2×10^{-7}	(8.1×10^{-3})
3,500	1.1×10^{-12}	(4.1×10^{-8})	1.4×10^{-7}	(5.2×10^{-3})
4,500	7.7×10^{-13}	(2.8×10^{-8})	1.1×10^{-7}	(4.1×10^{-3})
7,500	3.6×10^{-13}	(1.3×10^{-8})	5.5×10^{-8}	(2.0×10^{-3})
15,000	1.5×10^{-13}	(5.6×10^{-9})	2.5×10^{-8}	(9.3×10^{-4})
25,000	6.7×10^{-14}	(2.5×10^{-9})	1.2×10^{-8}	(4.4×10^{-4})
35,000	4.3×10^{-14}	(1.6×10^{-9})	8.3×10^{-9}	(3.1×10^{-4})
45,000	2.9×10^{-14}	(1.1×10^{-9})	5.8×10^{-9}	(2.1×10^{-4})
55,000	2.0×10^{-14}	(7.4×10^{-10})	4.2×10^{-9}	(1.6×10^{-4})
70,000	9.7×10^{-15}	(3.6×10^{-10})	2.3×10^{-9}	(8.5×10^{-5})

(1) Maximum off-site concentration occurs north-northeast of site on plume centerline.

(2) Inside site boundary, maximum concentration occurs due north of site on plume centerline.

(3) u = microcuries

whole body of any member of the public (40 CFR 61). Exposures relating to each of these facility limits are addressed below. An additional calculation of interest is the projected collective radiation exposure to the entire population resulting from routine releases.

From the maximum anticipated annual release of 16.4 microcuries (6.1×10^5 becquerel) during the 65-week project, an effective committed dose equivalent to the combined population within 80 kilometers of the site was calculated to be 0.16 person-rem (0.0016 person-sievert). Over a 52 week period the annual effective committed dose equivalent to the combined population of 2,598,114 was calculated to be 0.13 person-rem (0.0013 person sievert) with an average effective committed dose equivalent of 4.8×10^{-5} millirem (4.8×10^{-7} millisieverts). Thus, the average annual individual exposure is a small fraction of the effective committed dose equivalent limit of 1.0 millisievert per year applicable to the FMPC (Table 4-3).

The same model was used to calculate the dose to a hypothetical individual who resides at the site boundary at the point of maximum annual concentration of Th-232. Annual routine releases give this maximum individual an effective committed dose equivalent of 0.17 millirem (1.7×10^{-3} millisieverts). This exposure is a small fraction of the DOE-prescribed maximum individual limit of 100 millirem per year (1.0 millisievert per year) applicable to the FMPC (Table 4-3). Total calculated exposure to this maximum individual over the 65-week project would be 0.22 millirem (2.2×10^{-3} millisieverts).

The EPA limit of 75 millirem (0.75 millisievert per year) committed dose equivalent to the critical organ or 25 millirem (0.25 millisievert per year) dose equivalent to the whole body applies to a member of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides. For the FMPC site, this point is approximately 250 meters north of the site boundary at an existing residence. An individual at this location is estimated to receive a committed dose equivalent to the critical organ of 2.7 millirem (2.7×10^{-2} millisieverts) on an annual basis.

The critical organ i.e., most exposed human organ for exposure to Th-232 oxide from airborne emissions is the bone surface. The estimated whole body dose equivalent to the maximum individual is 3.8×10^{-3} millirem (3.8×10^{-5} millisievert). The total calculated dose equivalent to this individual using the 65-week life of the project would be

TABLE 4-3
RADIATION EXPOSURES FROM ROUTINE THORIUM HANDLING OPERATIONS

RECEPTOR	CALCULATED DOSE[5]	ANNUAL DOSE LIMIT FOR ALL FMPC OPERATIONS
Annual Effective Dose Equivalent to Average Occupational Worker rem (millisieverts)	___	5 (50)[1]
Effective Committed Dose Equivalent to Total Population, (person-millirem) (person-sieverts)	.13 (1.3×10^{-3})	none
Effective Committed Dose Equivalent to Average Individual, millirem (millisieverts)	4.8×10^{-5} (4.8×10^{-7})	100 (1.0)[2]
Effective Committed Dose Equivalent to Maximum Individual, millirem (millisieverts)	0.17 (1.7×10^{-3})	100 (1.0)[2]
Whole Body Dose Equivalent to Maximum Individual, millirem (millisieverts)	3.8×10^{-3} (3.8×10^{-5})	25 (0.25)[3]
Committed Dose Equivalent to Critical Organ, millirem (millisieverts)	2.7 (2.7×10^{-2})[4]	75 (0.75)[3]

(1) DOE, 1986.
(2) DOE, 1987.
(3) 40 CFR 61, Subpart H.
(4) In this case, the critical organ is the bone surface.
(5) Doses shown are for proposed action. Doses from alternate actions will be identical, with the exception of the no-action alternative. Doses for the no action alternative will be approximately 15 times greater.

4.9×10^{-3} millirem (4.9×10^{-5} millisieverts), with a committed dose equivalent to the bone surface of 3.4 millirem (3.4×10^{-2} millisieverts).

Table 4-3 summarizes annual effective dose equivalents to members of the public and compares them with applicable dose limits. These exposures apply to the proposed action, rail shipment alternative, interim storage alternative. Routine annual exposures associated with the no-action alternative were calculated to be approximately 15 times higher than those associated with the proposed action.

Radiological Exposures Resulting from Accidents

The radiological exposures resulting from postulated accidents would be a function of the immediate conditions prevailing at the time of each event. In all cases, releases would be of short duration, measured in minutes, and the cloud of particulates would be subject to the existing meteorological conditions (wind speed, wind direction, and atmospheric stability). Occupational workers at the scene of the accident would be trained to move up-wind of the release, put on appropriate respiratory equipment, and then respond to mitigate the magnitude of the accident.

Radiological exposure of the public as a result of postulated accidents was conservatively estimated by assuming that very stable meteorological conditions exist for the duration of the cloud passage. Wind speed was fixed at two meters per second and Pasquill atmospheric stability category F conditions were assumed. These conditions would result in a slow-moving and concentrated cloud of particulates off-site.

For the purpose of dose assessment, it was assumed that a member of the public (maximum individual) was located at the FMPC facility site boundary in the downwind direction during cloud passage. This maximum individual was assumed to be exposed to the highest resulting air concentration of Th-232 particulates, that measured at the centerline of the plume.

Maximum downward air concentrations and surface deposition are summarized in Tables 4-4 the proposed action, rail alternative and interim storage alternative. Maximum consequences for the no action alternative are summarized in Table 4-5.

Table 4-6 summarizes the effective committed dose equivalent to this hypothetical individual for each of the postulated accidents. Because of the conservatism of the assessment

TABLE 4-4
PEAK AIR CONCENTRATION AND TOTAL GROUND DEPOSITION OF
TH-232 RESULTING FROM WORST CASE ACCIDENT FOR PROPOSED ACTION

DISTANCE (meters)	PEAK AIR CONCENTRATION (1) Ci/m^3	(Bq/m^3)	SURFACE DEPOSITION Ci/m^2	(Bq/m^2)
250[2]	$1.4x10^{-9}$	($5.2x10^{1}$)	$8.4x10^{-10}$	($3.1x10^{1}$)
750	$1.7x10^{-10}$	(6.3)	$1.2x10^{-10}$	(4.4)
1,500	$5.3x10^{-11}$	(2.0)	$4.0x10^{-11}$	(1.5)
2,500	$2.4x10^{-11}$	($8.9x10^{-1}$)	$2.0x10^{-11}$	($7.4x10^{-1}$)
3,500	$1.4x10^{-11}$	($5.2x10^{-1}$)	$1.3x10^{-11}$	($4.8x10^{-1}$)
4,500	$1.0x10^{-11}$	($3.7x10^{-1}$)	$9.3x10^{-12}$	($3.4x10^{-1}$)
7,500	$4.8x10^{-12}$	($1.8x10^{-1}$)	$4.8x10^{-12}$	($4.8x10^{-1}$)
15,000	$2.0x10^{-12}$	($7.4x10^{-2}$)	$2.2x10^{-12}$	($8.1x10^{-2}$)
25,000	$9.2x10^{-13}$	($3.4x10^{-2}$)	$1.0x10^{-12}$	($3.7x10^{-2}$)
35,000	$5.8x10^{-13}$	($2.2x10^{-2}$)	$6.7x10^{-13}$	($2.5x10^{-2}$)
45,000	$3.9x10^{-13}$	($1.4x10^{-2}$)	$4.5x10^{-13}$	($1.7x10^{-2}$)
55,000	$2.5x10^{-13}$	($9.3x10^{-3}$)	$3.0x10^{-13}$	($1.1x10^{-2}$)
70,000	$1.1x10^{-13}$	($4.1x10^{-3}$)	$1.3x10^{-13}$	($4.8x10^{-3}$)

(1) Peak air concentration occurs during cloud passage.

(2) Inside site boundary

TABLE 4-5
PEAK AIR CONCENTRATION AND TOTAL GROUND DEPOSITION OF TH-232 RESULTING FROM WORST CASE ACCIDENT FOR NO ACTION

DISTANCE (meters)	PEAK AIR CONCENTRATION (1) Ci/m^3	(Bq/m^3)	SURFACE DEPOSITION Ci/m^2	(Bq/m^2)
250[2]	$6.5x10^{-10}$	$(2.4x10^{1})$	$9.2x10^{-9}$	$(3.4x10^{2})$
750	$7.9x10^{-11}$	(2.9)	$1.3x10^{-9}$	$(4.8x10^{1})$
1,500	$2.4x10^{-11}$	$(8.9x10^{-1})$	$4.4x10^{-10}$	$(1.6x10^{1})$
2,500	$1.1x10^{-11}$	$(4.1x10^{-1})$	$2.2x10^{-10}$	(8.1)
3,500	$6.5x10^{-12}$	$(2.4x10^{-1})$	$1.4x10^{-10}$	(5.2)
4,500	$4.6x10^{-12}$	$(1.7x10^{-1})$	$1.0x10^{-10}$	(3.7)
7,500	$2.2x10^{-12}$	$(8.1x10^{-2})$	$5.3x10^{-11}$	(2.0)
15,000	$9.1x10^{-13}$	$(3.4x10^{-2})$	$2.4x10^{-11}$	$(8.9x10^{-1})$
25,000	$4.2x10^{-13}$	$(1.6x10^{-2})$	$1.1x10^{-11}$	$(4.1x10^{-1})$
35,000	$2.7x10^{-13}$	$(1.0X10^{-2})$	$7.3x10^{-12}$	$(2.9x10^{-1})$
45,000	$1.8x10^{-13}$	$(6.7x10^{-3})$	$4.9x10^{-12}$	$(1.8x10^{-1})$
55,000	$1.2x10^{-13}$	$(4.4x10^{-3})$	$3.3x10^{-12}$	$(1.2x10^{-1})$
70,000	$5.0x10^{-14}$	$(1.9x10^{-3})$	$1.4x10^{-12}$	$(5.2x10^{-2})$

(1) Peak air concentration occurs during cloud passage.

(2) Inside site boundary

TABLE 4-6
DOSE CONSEQUENCES OF POSTULATED ACCIDENTS

ACCIDENT	RELEASE Curies (becquerels)	EFFECTIVE COMMITTED DOSE EQUIVALENT[1] millirem (millisieverts)	COMMITTED DOSE EQUIVALENT TO BONE SURFACE[1]
Drum Punctures	3.7×10^{-5} (1.4×10^{6})	8.6 (0.09)	137 (1.37)
Drum Ruptures	4.9×10^{-5} (1.8×10^{6})	11.4 (0.11)	181 (1.81)
Fire (Single Drum)	1.1×10^{-4} (4.1×10^{6}	26 (0.26)	411 (4.1)
Fire (19 Drums)	1.2×10^{-3} (4.4×10^{7})	278 (0.28)	4.4×10^{3} (44)
Siting and Design Limit[2]	- -	2.5×10^{4} (2.5×10^{2})	3.0×10^{5} (3.0×10^{3})

(1) Maximum calculated dose to any member of the general public.

(2) DOE Design Criteria, DOE 6430.1, Chapter 1 (DOE, 1983).

assumptions, these exposures should be considered to be at the upper range of the possible exposures that would occur from the postulated events.

Routine Transportation Impacts for Proposed Action

Radiation exposures resulting from proposed transportation activities were estimated based on the methods and analysis previously performed for the Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes (NUREG-0170, 1977). In that assessment, radiation doses resulting from routine transportation activities and projected accidental exposures during shipments of low specific activity (LSA) material (natural uranium oxide, U_3O_8,) were calculated. Modes of exposure included in this assessment were doses to transport crew, handlers, persons on and off the highway, and persons exposed during vehicle stops, and doses resulting from two-hour temporary storage times in transit. Sixty-nine percent of the total population dose for transportation activities involving the LSA uranium oxide material resulted from truck transport. The dose calculations were based on an average transport distance of 1,600 kilometers per shipment. The transportation route was assumed to be 5 percent urban (3,861 persons/km^2), 5 percent suburban (719 persons/km^2), and 90 percent rural (6 persons/km^2).

The uranium oxide shipments were classed as Type A LSA shipments. The Transportation Index (TI) (defined in 49 CFR 173 as the dose rate in millirem per hour at a distance of three feet from the surface of the package used in the analysis was 2.6 per package, with 40 packages per shipment and 1,600 truck shipments per year. Thus, the transportation index for the shipment was assumed to be 104. The resulting dose was determined to be 485 person rem per year, or an average of 1.6×10^{-4} person-rem (1.6×10^{-6} person-sieverts) per kilometer for each shipment.

This model was used to provide an upper limit to the anticipated dose contribution from the proposed action and alternatives. Routine shipments of LSA thorium material may be expected to result in doses of the same order of magnitude as calculated for a shipment of uranium oxide. An upper bound transportation for the proposed routine shipment of thorium material was estimated by comparing the measured dose rate from a slab array of thorium drums on site to that assumed in the NUREG-0170 analysis. The TI for the FMPC thorium material shipments has been projected to be 40 (Walker, 1987b). (The TI equivalent may be derived from 49 CFR 173 dose rate limits for exclusive use vehicles which apply at a distance of three feet from the outside lateral surface of the transport.)

The population dose estimated using the NUREG model should be considered as an upper limit to anticipated transportation doses from the proposed activity and alternatives. The dose model includes contributions to exposure from in-transit storage of radioactive materials, exposure to handlers along the route, and from vehicle stop time. Since thorium material shipments will be made "exclusive use" vehicles and shipments will go directly from the FMPC plant to the NTS storage site, the total population dose estimated during the 65-week thorium shipment period is 65.5 person-rem (.65 person sievert).

Dose contributions to the vehicle crew are also included in the total population dose calculated using the NUREG model. Actual dose rates in the cab of vehicles carrying thorium materials will be controlled by shielding to within the allowable 2 millirem per hour (.01 millisievert per hour) dose rate in accordance with DOT requirements for exclusive-use shipments, and will be kept as low as reasonably achievable (ALARA) in keeping with DOE goals.

Routine Transportation Impacts for Alternatives

Rail Shipment

Shipment of thorium material by rail would result in impacts similar to those of truck transport. An upper limit to these consequences may be estimated by using the rail transport doses derived for the shipment of uranium oxide in the NUREG 1977 study. It was estimated that railcar shipments of 40 drums of uranium oxide results in a population exposure of 5.7×10^{-5} person-rem kilometer for each railcar shipment. Following the methodology outlined for truck shipments of thorium material from FMPC, with 2 trailers per railcar and 20 railcars per train would result in a population exposure of 12 person-rem.

Shipment of thorium material to the Nevada Test Site by rail and truck combination (see Section 3.2.1) has the following advantages over full-distance trucking: (1) number of shipments would be reduced if larger quantities are shipped on a railcar; (2) accidental spillage (low probability) is less likely to affect humans because of lower population density along rural rights-of-way where potential accidents are more probable than in urban areas; (3) dose commitments to short-haul truck crews are far less than for full-distance truck crews; and (4) dose commitment to the general public is less because of the lower population along railroad rights-of-way, if inner-city routes can be avoided.

Disadvantages of rail shipments of thorium material include: (1) logistical problems in consolidating loading and unloading thorium material and administering DOE exclusive-use "dedicated train" through different geographical jurisdictions; (2) reduced flexibility in selecting alternate routes after shipment of a given railcar load has begun, (3) reduced administrative control of individual shipments by the shipper and carrier organizations, and (4) greater ecological impact of accidental spillage if larger quantities are shipped on a railcar rather than on a truck.

Storing Thorium Material On-Site

Thorium materials stored on site will not require transportation. Any decision to transport the wastes later will have similar consequences as the proposed alternatives.

No Action

There are no transportation impacts associated with the no-action alternative.

4.1.3.2.3 Transportation Accidents

For the transportation accident scenario, it is assumed that 10 percent of the contents of a shipment could be spilled over 100 square meters of road surface. The resulting surface contamination level is $2x10^{-3}$ curies per square meter ($7.5x10^{7}$ becquerels per square meter). The exposure rate in air at one meter above the contaminated surface would be about 0.5 milliroentgen per hour ($5x10^{-3}$ millisieverts per hour), which is not significant in terms of potential direct radiation exposure.

The primary mode of radiation exposure to emergency response personnel and onlookers would be via inhalation of airborne thorium particulates. For the purpose of assessing this exposure, it is assumed that the spill remains uncovered for a one-hour period and that 0.2 percent of the spill, 0.4 millicurie ($1.5x10^{7}$ becquerels), is resuspended by aerodynamic entrainment (Mishima, et al., 1973). It is assumed that a member of the public is located 100 meters directly downwind of the accident scene over this period of time and that stable atmospheric conditions, Pasquill atmospheric stability category F two-meter-per-second wind speed, prevail. Under these conditions, this individual would receive a committed effective dose equivalent of 4.7 rem (47 millisieverts) due to the inhalation of thorium particulates. This exposure would be accrued over a 50-year period as a result of retention of the thorium in the body. The worst single year of exposure is the fifteenth, during

which a 114 millirem (1.14 millisievert) effective dose equivalent results. This worst annual exposure is comparable to that received from natural background radiation in any given year. Emergency response personnel would wear respiratory protection and would not be subject to significant inhalation exposure.

For the rail transportation alternative, dose consequences are expected to be identical to those described above. The interim storage and no-action alternatives do not involve offsite transportation.

4.2 ENVIRONMENTAL IMPACTS

This section addresses potential impacts of the proposed action and the alternatives on the important local and regional resources.

4.2.1 Air Quality

4.2.1.1 Proposed Action

Air quality impacts for the proposed action will be inconsequential. Criteria pollutant concentrations are well within NAAQS standards as shown in Table 4-1. Radiological releases under routine operations result in a maximum annual average offsite concentration of 1.1×10^{-11} microcuries per cubic meter (4.1×10^{-7} becquerels per cubic meter).

For comparison, this concentration is a small fraction of the Derived Concentration Guide for Th-232 in air, 1×10^{-8} microcuries per cubic meter (3×15^{4} becguerels per cubic meter), applicable to combined routine releases from all FMPC operations (DOE, 1987). The worst-case accident postulated for the proposed action results in a higher short term air concentration offsite. The significance of air concentrations of Th-232 from postulated accidents is evaluated in terms of dose consequences in Section 4.2.8.

4.2.1.2 Alternatives

Air quality impacts for all the alternatives are inconsequential. The actual impacts for routine releases associated with the rail alternative and interim storage alternative are identical to those for the proposed action. There are no routine releases associated with the no-action alternative. The significance of accident-related air concentrations for the alternatives are evaluated in terms of dose consequence in Section 4.2.8.

4.2.2. Geology and Soils

4.2.2.1 Proposed Action

4.2.2.1.1 Geology

Impacts on the local geology will be inconsequential. The proposed action and alternative actions involve no construction activity or excavation.

4.2.2.1.2 Soils

The Thorium Handling Environmental Assessment (DOE, July 1987) indicates the type of thorium compounds stored at FMPC are commonly found throughout the United States and contribute to the existing "background" alpha-radioactivity in the upper levels of the soil horizon. Background radioactivity levels in the upper soil horizon due to the presence of Th-232 averages about 1×10^4 becquerels per square meter (Whicker, 1987). The projected release from the one-time thorium handling required for the proposed action would contribute only 1×10^{-5} of the amount of existing background levels. The impact of the proposed action on soils would be negligible and not significant. The potential for a spillage due to a transportation accident is low because of the multiple layers of containment protection provided by the drums and shipping containers. With implementation of immediate cleanup procedures the short and long term impacts on soils are expected to be low and not significant

4.2.2.2 Alternative Actions

4.2.2.2.1 Shipment of the Thorium Material by Rail

Impacts on geology and soils from the rail alternative would not be significant. The potential for a release of thorium in the event of an accident remains low. Although a greater quantity of material can be carried at one time in a rail car, or group of railcars than in a truck, the shipping containers provide additional protection and any spillage due to an accident is expected to be minimal. However, because of the larger quantities transported per carrier, the potential for a spill at the site of a train accident is larger than under the proposed action transport system.

4.2.2.2.2 Onsite Storage

Impacts on geology and soils from the on site storage alternative would be negligible under short-term conditions because the materials will be overpacked and repacked

reducing contamination of the abiotic environment significantly. A possible adverse effect of this alternative action, however, could arise from storing the materials for a prolonged period of time allowing deterioration and corrosion of the containers to occur again. A potential for surface contamination would prevail under these conditions. Only through the continual monitoring of the stored material and immediate action to alleviate possible corrosion could this alternative action be considered.

4.2.2.2.3 No Action

Surface contamination could occur in the event of the no action alternative and have a long-term adverse effect on soil and air water quality due to the continual release and dispersion of the thorium oxide materials. The adverse environmental impact of the no action alternative greatly outweighs its potential as a viable alternative.

4.2.3 Hydrology and Water Quality

4.2.3.1 Proposed Action

Releases to surface water during this proposed action are not anticipated. There will not be any discharge of material to the FMPC process waste stream, the sanitary waste stream, or the storm sewer system. In addition, none of the existing storage warehouses are located in proximity to, or within, the floodplain of a natural stream. The Thorium Handling Environmental Assessment (DOE, July 1987) indicates thorium could potentially enter surface waters through three pathways:

1) Surface deposition of airborne particulates

2) Run-off of precipitation (rain or snow) from the current thorium storage areas to off-site areas

3) Spills of decontamination water used to clean equipment

Similar pathways could be involved in the proposed action. The maximum total surface deposition of TH-232 during routine operations has been calculated DOE 1987) to be 7.9 x 10^{-3} becquerels per square meter. Assuming an average mixing depth in nonflowing water at one meter results in a surface water concentration of 7.9 x 10^{-9} becquerels per milliliter. This is far below the allowable concentration of Th-232 in water of 1.5 becquerels per milliliter (DOE, 1981). Therefore, surface deposition of airborne thorium particulates would be insignificant (Table 4-2). The

proposed action will significantly decrease the likelihood of surface contamination that increases the possibility of run-off to surface water because the drums will be completely contained. Surface water contamination caused by precipitation run-off from the FMPC as a result of this project is not expected to occur because of implementation of the spill prevention, control and countermeasure plan for the FMPC. It is highly unlikely that these environmental controls, which are integral to the entire facility, would malfunction or fail to operate. Additional mitigation measures (Section 5.0) such as placing an tent over the outside work areas and placing berms around the outside work areas to interdict surface run-off would contribute to maintaining negligible impact on water resources. The potential for spills during transport is low because the multiple containment protection provided by the drums and shipping containers. Precipitation at the time of a spill and during cleanup operations could cause contamination to surface waters by run-off from the spill site.

4.2.3.2 Alternative Actions

4.2.3.2.1 Rail Shipment of Thorium Materials

Impacts during the project activities on the FMPC site are the same as discussed for the proposed action.

Hazards to the local hydrology during shipment are expected to be inconsequential. However, in the unlikely event of a spill, during an accident, some contamination to surface water could occur as run-off from the spill site.

4.2.3.2.2 On-site Storage

Adverse effects on the local hydrology from this alternative action could be significant if the material, after it has been stored for a prolonged period of time, deteriorates and corrodes, introducing the possibility of surface water contamination from runoff.

4.2.3.2.3 No Action

A long-term adverse impact on water resources may be expected if the no action alternative is selected and no action is taken to contain the deteriorating drums. Thorium deposition could result in surface water contamination via runoff and not only affect available water resources but possibly affect aquatic organisms as well.

4.2.4 Biological Resources

4.2.4.1 Proposed Action

The effect of the proposed action on the vegetation and wildlife (including threatened and endangered species) are expected to be negligible and not significant. The location of the proposed action within the FMPC production area isolates the activities from the biological resources of the area. To have a significant effect, the airborne deposition on land to soils and surface water (Section 4.1.3) would have to be greater by several orders of magnitude. The potential for a spill due to a traffic accident during transport exists but is considered low because most of the thorium is isolated within smaller containers within shipping containers. Significant affects on biological resources are not expected to occur.

4.2.4.2 Alternative Actions

Impacts on biological resources by the rail alternative are not significant, but are similar to those of the proposed action. The on-site storage alternative does not directly affect the biological resources, although deterioration of shipping containers over the long term could result in a release of thorium and subsequent adverse impacts on the biota. Impacts on biotic resources from the no action alternative could be adverse if the current deteriorating conditions were to persist for a prolonged period of time.

4.2.5 Land Use

4.2.5.1 Proposed Action

The proposed action will not adversely affect land use patterns. However, more usable land space within the production area may be made available by the removal of the drums from the existing locations on the site.

4.2.5.2 Alternative Actions

Impacts due to the rail alternative would be similar to the proposed action and not affect land use in the area.

Impacts on land use from the on-site storage alternative would not be beneficial. Shipping container storage would continue to monopolize various locations of the production area and reduce overall available space.

The no-action alternative would have a severe adverse effect on land use in the immediate storage areas due to contamination from the corroding drums which could result in the releases reaching toxic levels.

4.2.6 Cultural Resources

4.2.6.1 Proposed Action

No adverse effects are anticipated to affect the cultural paleontological resources.

4.2.6.2 Alternative Actions

Cultural and paleontological resources would not directly be affected by any of the alternative actions.

4.2.7 Socioeconomics

4.2.7.1 Proposed Action

There will be no significant impact on the socioeconomic conditions either in the form of significant noise, traffic, or additional employment. No construction activities are involved.

4.2.7.2 Alternative Actions

1. No change in socioeconomic conditions would occur in relation to the rail alternative.

2. No significant impacts on socioeconomic conditions from the on-site storage alternative are expected to occur.

3. Under the no action alternative the potential continued deterioration of the existing drums would have no direct significant impacts on the socioeconomics of the region.

4.2.8 Health Impacts

The health consequences of radiation exposure to a hypothetical individual, resulting from routine thorium handling and repackaging activities and postulated accidents is principally an increase in the risk of cancer.

Potential risks to human health from routine operations related to thorium handling and postulated accidents are compared in Table 4-7. With respect to human health risks, the consequence of radiation exposure is reported as a risk of contracting a fatal cancer at any time in the future as a

TABLE 4-7
HEALTH RISK COMPARISON: RADIOLOGICAL EXPOSURE TO INDIVIDUALS[1]

ACTION	ROUTINE OPERATIONS			POSTULATED WORST ACCIDENT[2]
	OCCUPATIONAL WORKER AVERAGE[3]	PUBLIC AVERAGE INDIVIDUAL[4]	PUBLIC MAXIMUM INDIVIDUAL	PUBLIC MAXIMUM INDIVIDUAL
Proposed Action				
Thorium Repackaging	5×10^{-4}	6×10^{-15}	2×10^{-11}	3×10^{-6}
Truck Transport[5]	5×10^{-6}	2×10^{-9}	7×10^{-9}	5×10^{-7}
Alternative 1:				
Thorium Repackaging	5×10^{-4}	6×10^{-15}	2×10^{-11}	3×10^{-6}
Rail Transport[5]	8×10^{-7}	8×10^{-10}	3×10^{-9}	5×10^{-7}
Alternative 2:				
Thorium Repackaging	5×10^{-4}	6×10^{-15}	2×10^{-11}	3×10^{-6}
No Transport				
Alternative 3:				
No Action				3×10^{-5}

(1) Health risks are expressed as the probability of an individual contracting a fatal cancer from the activity during his lifetime.
(2) The health risk assuming that the worst accident occurs; i.e., the probability of the accident is not included.
(3) Health risk based upon assumption that involved worker exposure will be maintained below 10 millisieverts.
(4) No incremental routine exposure to the public should result.
(5) Health risks for routine transportation activities are assumed to be bounded by the range established in Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes, NRC, 1977.

result of the estimated radiation exposure. In the health risk assessment, the following accepted principles have been employed:

- A carcinogenic risk due to radiation exposure is defined as the probability that a specified dose will cause fatal cancer in some fraction of the people exposed.

- Dose-response relationship is chosen to be linear with no threshold, i.e., it is assumed that the probability of late stochastic effects (somatic and genetic) are proportional to radiation exposure received no matter how small that exposure.

- Dose response is considered to be independent of dose rate (BEIR 80).

The absolute risk model as set forth by the Committee on the Biological Effects of Ionizing Radiation (BEIR, 1980) was used in addition to reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UN, 1977) and the ICRP (ICRP, 1977).

4.2.8.1 Proposed Action

Health impacts were evaluated for proposed transportation and thorium handling activities. The radiation doses projected for both routine and potential accident conditions were used as a basis for this evaluation. The discussion of radiation doses resulting from transportation is presented in Section 4.1.3.3. Radiation dose consequences from on-site activities are given in Tables 4-3 and 4-6. The health effects associated with a fire in a drum of pyrophoric material were evaluated as the worst-case accident. The risk of contracting a fatal cancer over the lifetime of exposed individuals is presented in Table 4-7. These risks consider only the exposures associated with releases of Th-232 and do not include the risk of cancer from other environmental causes. The risk of cancer during the lifetime of an individual resulting from all natural and man-made causes has been estimated at 26 percent (BEIR, 1980). As shown in Table 4-7, the increased risk represented by the proposed action is negligible by comparison.

4.2.8.2 Alternative Actions

4.2.8.2.1 Rail Shipment of Thorium Material

Health effects associated with this alternative differ from the proposed action only in transportation risks. Routine transportation activities would result in health risks of the same order of magnitude as the proposed alternative as shown on Table 4-7. The increased risk of contracting a fatal cancer represented by this alternative is also negligible in comparison with that from all other natural and man-made causes.

4.2.8.2 On-site Storage

The health risks associated with the on-site storage alternative are virtually identical to the proposed action minus the small risks associated with transportation. Table 4-7 shows the health risks of this action in comparison to the proposed action and other alternatives.

4.2.8.2.3 No Action

The health risks for the no-action alternative are expected to be about 10 times worse than for the proposed action in the event of a projected accident. The health risks associated with this alternative in comparison to the proposed action and other alternatives are shown in Table 4-7.

4.3 CUMULATIVE IMPACTS

The proposed project includes repackaging and/or over packing approximately 17,000 containers of thorium materials and shipment of a total of 1100 metric tons of thorium material to the NTS.

Cumulative impacts due to the two thorium projects may take place if accidental spills occur simultaneously during the period of overlap in the two handling processes. However, because of the spill containment procedures that will be in place, the release of airborne particulates and material to surface or groundwater will be minimal. Therefore, the expected cumulative impacts on environmental resources would be negligible and not significant.

With implementation of the appropriate containment and clean up program for any accidental release, cumulative impacts due to the proposed action, the silo and bin decommissioning, and other ongoing operations within the FMPC site would also be expected to be minimal.

4.4 UNAVOIDABLE ADVERSE EFFECTS

Effects of this proposed action are short term only, in the form of airborne particulates of Th-232 and criteria pollutants CO, NO_2, SO_2 and particulates. Thorium may be released even with all environmental controls systems in place and operating. These effects however can be offset by implementing proper health and safety precautions which includes the spill prevention and control program in the event of an accidental spill that could result in surface contamination.

4.5 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The thorium materials to be repacked and/or overpacked for transport to the Nevada Test Site will be maintained in a retrievable capacity at the Nevada Test Site. Therefore, no significant irreversible and irretrievable commitment of resources will take place.

4.6 COMPARISON OF ENVIRONMENTAL CONSEQUENCES

The environmental consequences of the proposed action are significantly less than that of the on-site storage and no action alternatives. The rail alternative is, in a few ways, a safer alternative to full-distance truck transport but due to previously discussed obstacles (Section 2.3), is not presently a viable option

The comparative impact matrix (Table 4-8) is divided into short-term (5 years or less) and long-term (5 years or more) impact levels and is related to the stages involved for each action.

The proposed action and the rail transport alternative are similar in short- and long-term impacts and they have lower long term impacts than the onsite storage and no-action alternatives.

TABLE 4-8. COMPARATIVE IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

Environmental Parameters \ Proposed Action vs. Alternative Action	Proposed Action				Alternative Actions									
	Repack		Transport		Rail Transport				On Site Storage				No Action	
					Repack		Transport		Repack		On Site Storage			
	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Soils	■	■	■	■	■	■	■	■	■	■	■	○	■	○
Air Quality	○	●	■	—	○	●	■	—	○	●	■	○	○	○
Ground Water Quality	■	●	■	—	■	●	■	—	■	●	■	○	■	○
Public Health	■	●	○	■	■	●	○	■	■	●	■	○	■	○
Worker Health/Safety	○	●	○	■	○	●	○	■	○	●	■	○	■	○
Vegetation	■	●	■	—	■	●	■	—	■	●	■	■	■	■
Wildlife	■	●	■	—	■	●	■	—	■	●	■	■	■	■
Aquatic Ecosystems	■	●	■	—	■	●	■	—	■	●	■	■	■	■
Threatened/Endangered Species	■	●	—	—	■	●	—	—	■	●	■	■	■	■
Cultural Resources	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Visual Resources	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Land Use	■	●	—	—	■	●	—	—	■	●	■	○	○	○
Noise	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Traffic	—	—	■	—	—	—	—	—	—	—	—	—	—	—
Employment	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Duration: S--Short-term--5 years or less (immediate effects of action)
L--Long-term--5 or more years

○ Adverse environmental impact
● Beneficial environmental impact
— not applicable
■ no significant environmental impact

5.0 MITIGATION MEASURES

Mitigation measures have been incorporated into the description of the proposed action and alternatives. When implemented effectively, these measures help reduce impacts to the levels identified in Section 4. Additional mitigation measures suggested to reduce radiation hazards during handling of the material or in the event of spills or other accidental releases include the following:

1) The provision of awnings or temporary covering over the outdoor work areas including the storage area adjacent to FMPC Building 65, as well as the areas around the doorways to FMPC Buildings 64, 65, 67 and 68 to protect the drums and workers from inclement weather and reduce the potential surface run-off of contaminated materials.

2) The provision of berming around the work areas to minimize the impacts of spills by eliminating the potential of sheet-flow run-off, during periods of precipitation, carrying contaminated materials away from the work site.

6.0 PERSONS AND ORGANIZATIONS CONSULTED

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GLOSSARY

Accident Scenario:	Description of unforeseen events or circumstances that have a finite but low probability of occurring during the duration of the project.
Aerodynamic Equivalent Diameter:	The diameter of a uniform density sphere that would have the same velocity due to gravity in air as the particle under consideration.
ALARA:	DOE objective to maintain radiological exposure levels to as low as reasonably achievable.
BEIR:	Biological Effects of Ionizing Radiation (National Academy of Sciences Committee).
Becquerel (bq):	A unit measuring the radioactivity of an element. One becquerel is defined as one nuclear disintegration per second.
CEQ:	U.S. Council on Environmental Quality.
CO:	Carbon monoxide.
Committed Dose:	The radiation dose received during the period of exposure plus the dose accumulated over a period of years of exposure (in this case, 50 years) resulting from radionuclide deposited within the body during the exposure period.
Coniferous:	Pertaining to cone-bearing species such as pines.
Critical Organ:	The human body organ receiving a radiation dose that results in the greatest overall damage to the body.
Curie:	A unit measuring the radioativity of an element. One curie is defined as $3.7X10^{10}$ nuclear disintegrations per second.
DOE:	U.S. Department of Energy.
DOT:	U.S. Department of Transportation.
Deciduous:	Pertaining to a tree or shrub that sheds its leaves seasonally.

Diatomaceous Earth:	Earth material abounding in fossilized plankton.
Dispersion:	The process of natural mixing in the atmosphere.
Dose:	A general term denoting the quantity of radiation energy absorbed in biological tissue. The unit of dose is a sievert.
Dose Equivalent:	The product of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of the radiation and its distribution in the human body. The unit of dose equivalent is the sievert.
Dose Response:	The immediate and long-term effects of exposure to a radiation dose.
EPA:	U.S. Environmental Protection Agency
Edge Habitat:	The transition zone betwen two plant communities.
Effective Dose Equivalent:	The sum of the products of the dose equivalents to individual organs and tissues, and appropriate weighting factors representing the risk relative to that of an equal dose to the whole body. The unit of effective dose equivalent is the sievert.
Environment:	The physical and biological surroundings existing for humans, plants, and animals. Includes atmosphere, water, and land as well as the environment "built" or developed by man.
Environmental:	Pertaining to biosphere. The complex physical chemical, and biotic factors that act upon an organism.
Environmental Impact:	The consequences, effects or outcomes resulting from changes in the human or natural environment. In this EA, impacts are generally confined to human health effects or adverse effects on natural ecosystems.

Exposure:	The absorption of ionizing radiation or ingestion/inhalation of a radionuclide. The product of dose rate and time.
FMPC:	Feed Materials Production Center, Fernald, Ohio
Forb:	Broad-leaved herbaceous plant as distinguished from the grasses.
HEPA:	High efficiency particulate air filter capable of removing at least 99.97 percent of airborne particulates greater than 0.3 microns in diameter.
Habitat:	The physical environment where an organism lives.
Herbaceous:	Non-woody plants.
Millisievert:	One thousandth (0.001) sievert, equal to 10 millirem.
NEPA:	National Environment Policy Act.
NO_x:	Nitrogen oxides.
NPDES:	National Pollutant Discharge Elimination System. Refers to a type of State of Ohio or federal permit for discharging wastewater to a surface water body. Derives from Section 402 of the federal Clean Water Act.
NTS:	Nevada Test Site.
National Register of Historic Places:	A listing and designation of nationally significant historical or archeological sites given special protection under the federal Historic Preservation Act. The National Register is managed by the National Park Service.
OSHA:	U.S. Occupational Safety and Health Administration.
Off-Site:	Any location beyond the site boundary where a member of the public can be legally situated beyond the control of the owner and operator of a nuclear facility.

Paddy's Run:	An intermittent stream (flowing only part of the year) running from north to south along the western boundary of the FMPC.
Population Dose:	An estimate of total radiation dose received by members of a population group (units are person-sieverts).
Radon 220:	A naturally occurring radioactive gas created in the radioactive decay of thorium, often called thoron.
Rare, Threatened, or Species:	A classification of a terrestrial or aquatic plant or animal species given special protection under the federal Endangered Species Act.
Rem:	Acronym of roentgen equivalent man. The unit of radiation dose equivalent that expresses all kinds of radiation on a common scale.
Riparian:	Along the bank of a river or lake.
Roentgen:	A unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions.
Ruderal:	A type of disturbed habitats.
SO_2:	Sulfur dioxide.
Sievert:	A unit of radiation energy deposited in tissue equivalent to one joule per kilogram.
Site Boundary:	The boundary of a property over which the owner or operator can exercise strict control without the aid of outside authorities. The site boundary does not have to be a fence or other physical barrier.
Site-Specific Data:	Data collected for use in radiological assessment models applicable to the particular location for which assessment is performed.
Somatic:	Radiation effects manifested in the exposed individual.
Source of Term:	The amount of radioactive material released from primary confinement to the biosphere in dispersible form (units are becquerels).

Species Diversity:	A measure of the variety of different species of a community. Describes the number of species within that community and their relative abundances.
Stochastic:	Effects whose probability of occurrence in an exposed population is a direct function of dose.
Taxa:	Plural of taxon.
Taxon:	In taxonomy a unit of any rank such as a particular species, genus, family, order, class, etc.
Third-Order Stream:	Classification of stream based on size. Third-order streams are formed by the joining of two second-order streams that have lower yearly flow.
Thorium:	A naturally occurring radioactive element.
TI:	Transportation Index.
Transportation Index:	Defined by Department of Transportation regulations 49 CFR 173 as the radiation dose rate in millirem per hour at a distance of 0.194 meters (3 feet) from the package to be transported.
Unrestricted Use:	Meeting regulatory criteria established to protect public safety in any type of future use.
WMCO:	Westinghouse Materials Company of Ohio.
Working Level (WL):	Any combination of radon daughters in one liter of air that will result in the ultimate emission of 1.3×10^5 Mev of potential alpha decay particle energy.
Worst Case:	Calculation made based on assumptions intended to bias results toward overestimation of negative impacts.

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DOSE ASSESSMENT METHODOLOGY

This appendix provides an overview of the methodology and assumptions used to assess the radiological consequences to members of the public from airborne radioactivity releases from the FMPC facility.

A.1 DOSE CALCULATION MODELING

The AIRDOS-EPA computer code was used to estimate the radiation dose to man resulting from the atmospheric release of radionuclides from thorium material removal activities at the described in Moore, 1979 and was used for both routine and accidental release assessments. Most input parameters required by the code characterize the area surrounding the site or are specific to the radionuclides released. As such, these input data were identical for both release assessments. Other input, such as the source terms and the meteorological assumptions used, were specific to the release assessment. The following discussion differentiates between routine release modeling and accident release modeling where differences exist. Unless otherwise specified, the input data for the AIRDOS-EPA code were provided by Oak Ridge National Laboratory, which is currently preparing the Environmental Impact Statement for the Fernald Site.

A.2 OVERVIEW OF AIRDOS-EPA

In general, AIRDOS-EPA estimates the radiation dose to either a maximum individual or to a collective population resulting from the airborne release of radionuclides specified as input to the code. Based upon a characterization of the area surrounding the site and the meteorological conditions specified, the code estimates: (1) concentrations of radioactivity in air, (2) rates of deposition on ground surfaces, and (3) ground surface concentrations. These results are then coupled with intake rates for man to estimate the radiation dose to an adult receptor associated with all possible exposure pathways. For a maximum individual, doses are calculated along the release plume centerline. For a collective population dose, the model calculates an average concentration of the release plume for each sector (distance and direction pair) and uses this calculation to compute a dose.

A.3 METEOROLOGICAL MODELING

The area surrounding the FMPC site was modeled as a 80-kilometer radius circular grid system with the site located at the center. For the assessment of routine annual releases, site-specific meteorological data typical of annual average conditions were specified. First, the annual frequency of wind direction was determined for each of the 16 compass directions starting at

direction 1 for winds toward the north and then proceeding counter clockwise through direction 16. Next, the frequency of each Pasquill stability category for each of the 16 compass directions was determined for the six stability classes ranging from A (very unstable) to F (extremely stable). The average wind speed was entered for each wind direction and Pasquill category. The average depth of the atmospheric mixing layer (lid) for the area was specified to limit the vertical dispersion of the plume after it travels some distance downwind of the source. The value used for the lid height was 700 meters for releases due to routine operations and a more conservative 450 meters for accidental releases. The site-specific meteorological data used in the assessment of routine releases were taken from Greater Cincinnati International Airport and are summarized in Tables A-1 through A-4.

For the assessment of accidental releases, meteorological assumptions were specified to intentionally maximize the calculated dose consequences to a hypothetical off-site individual. The release was confined to a single 22.50 sector, and assuming a constant 2 meter per second wind speed, a comparison was made of the ground level air concentrations at all distances downwind for each Pasquill stability class. The stability class and distance resulting in the highest off-site air concentration of released radionuclides was assumed for the duration of the accident. The meteorological assumptions determined in this manner for the assessment of accidental releases as derived above are summarized in Table A-5.

A.4 EFFLUENT MODELING

AIRDOS-EPA requires input describing the area or point of release. Releases due to routine thorium removal activities were assumed to occur as a point source at ambient temperature (200C), 6.1 meters above the ground with an effective "stack" velocity of 2.54 meters per second due to ventilation exhaust velocity. Stack data input is given in Table A-6. Effective stack heights were estimated using Rupp's equation for momentum dominated plumes, Rupp, 1948. Accidental releases were calculated using both point source and an area source at ground level at ambient temperature and an effective "stack" velocity of 0.3 meters per second.

A.5 DISPERSION MODELING

The basic equation used to estimate plume dispersion in the downwind direction is the Gaussian plume model of Pasquill, 1961, as modified by Gifford, 1961.

The values of the horizontal and vertical dispersion coefficients (sy and sz) used for dispersion and depletion calculations are

those recommended by Briggs, 1969. With respect to deposition of radionuclides on ground surfaces, the code permits considering both dry deposition and scavenging. Dry deposition is the process by which particles deposit on grass, leaves, and other surfaces by impingement, electrostatic deposition, chemical reactions, or chemical reactions with surface components. The rate of deposition on earth surfaces is proportional to the ground-level concentrations of the radionuclides in air (Slade, 1986):

$R^d = Vdx$ where:
R^d = Surface deposition rate, pCi/cm^2-sec,
x_d = Ground level concentration in air, pCi/cm^3, and
V^d = Deposition velocity, cm/sec.

It should be noted that even though V^d has units of velocity, it is a constant of proportionality and as such must be experimentally determined from field studies in which the ratio R^d/x can be reliably determined. For particles less than 4 microns in diameter, V^d is set at 0.1 cm/sec (Heinemann, 1979). This value is, however, based on vegetation cut at a specific height and fails to measure total deposition on a unit area basis. The value must therefore be divided by the fraction of atmospherically depositing nuclides intercepted by the above-ground edible portion of the vegetation to arrive at a total value of V^d. Using a mean forage grass interception fraction of 0.57 produces a deposition velocity (V^d) of 0.18 cm/sec for small particulates. Since specific values for V^d (total) have not been published for vegetable crops, it is assumed that the value is the same as that used for forage.

The rate of deposition by scavenging is a function of the precipitation rate since it is principally a mechanism of washout of particles from a plume by rain or snow. The scavenging coefficient is averaged over an entire year which includes all periods during which rain or snow does not fall. The treatment of scavenging can thus be described as a continuous removal of a fraction of the plume per second over the entire year. The scavenging coefficient thus has units of sec^{-1}. The rate of scavenging (R_s) in pCi/cm^2-sec is:

$$R_s = Ox_{ave}L$$

where:
O = Scavenging coefficient, sec^{-1}
x_{ave} = Average concentration of nuclide in a column of air to the lid height, pCi/cm^3
L = Height of the lid, cm

The value for the total ground deposition rate used in assessing routine releases was the sum of the dry deposition and the

scavenging rates. For accident release assessment, the scavenging rate due to precipitation was conservatively ignored, thus maximizing the plume concentration. The code maintains a mass balance along the plume to reduce the concentration of the plume by accounting for removal of the deposited fraction.

A.6 TERRESTRIAL MODELING

As previously described, the area surrounding the FMPC site was modeled as a 80-kilometer radius circular grid system with the site located at the center.

For the circular grid, 13 distances were specified in each of the 16 compass directions, each distance representing the midpoint of a sector. The distances were specified as 250, 750, 1,500, 2,500, 3,500, 4,500, 7,500, 15,000, 25,000, 35,000, 45,000, 55,000, and 70,000 meters from the center of the site. Within each sector formed by the grid system, FMPC data used for population, agricultural and water area, and beef and dairy cattle were overlayed in arrays. These data are summarized in Table A-7.

Other factors used in modeling terrestrial and food crop transport are essentially those recommended by the U.S. Nuclear Regulatory Commission (NRC) (NRC, 1977). The period of time allowed for long-term buildup of radioactivity on surface soils was 150 days, the anticipated duration of thorium removal operations. The depth of the plow layer was assumed to be 15 cm with an areal density of 215 kg/m^2. The fallout interception fraction was set at 0.57 to be consistent with a deposition velocity of 0.18 cm/sec, reference 33. The fallout interception fraction for food crops is the NRC recommended value of 0.20. The weathering removal rate constant used was 2.9E-03 hr^{-1} and it was assumed that pasture grass was exposed for 720 hours during the growing season while crops were exposed for 1440 hours. Agricultural productivity for the grass-cow-milk path-way was set at 0.28kg/m^2 and for produce and leafy vegetables 0.716 kg/m^2. Foraging animals were assumed to be on pasture during the 150-day duration of thorium removal and received an additional food supply fraction of 0.47. Forage was assumed to be consumed at a rate of 15.6 kg/day dry weight, (Baes, 1984).

The muscle mass of the steers at slaughter was 200 kg. The fraction of the beef herd slaughtered each day is 0.0038 which allows for slaughter of 1/3 of the herd during the project. Bioaccumulation factors were taken from Baes, 1984. Dairy cow milk production was set at 11 liters/day. All of the leafy vegetables and other produce were assumed to be grown in the assessment area. These and other input parameters related to terrestrial modeling and food crop transport are summarized in Tables A-8 and A-9.

A.7 DOSE MODELING

Using the ground-level concentrations in air and ground deposition rates computed from the meteorological input, the code estimates intake rates at specified environmental locations and calculates the resultant doses through various modes of exposure. For the purpose of assessing the total dose to the population, the air concentrations and ground deposition rates are average values in the cross wind direction over each sector. The average individual dose is then determined by dividing the population dose by the number of individuals in the exposed population. The dose to a maximum individual is determined directly by the code and assumes that the individual is located on the center line of the discharge plume at the point of highest off-site ground-level concentration. Human inhalation rates, ingestion rates and other factors utilized in modeling the dose receptors are summarized in Table A-10.

The modes of exposure considered in the dose include the following pathways: (1) immersion in air, (2) exposure to contaminated ground surfaces, (3) inhalation of contaminated air, (4) immersion in water such as by swimming in a river or lake, and (5) ingestion of contaminated water and food grown on contaminated land. The total dose to each of the following organs was calculated: total body, lungs, red bone marrow, lower large intestine wall, stomach wall, kidneys, liver, endosteal cells, thyroid, testes and ovaries.

The doses calculated were 50-year dose commitments resulting from a one-year exposure for routine releases or one-time exposure for accident releases. (Only the most highly exposed organs are included in the results reported in the text.)

The dose conversion factors used in the calculation are those reported in Dunning, 1986. The inhalation factors are based on the ICRP Task Group Lung Model, which simulates the behavior of particulate matter in the respiratory tract. The inhalation factors used correspond to a median aerodynamic diameter of 0.3 microns. The ingestion factors are based on a four-segment catenary model with exponential transfer of radioactivity from one segment to the next. Retention of nuclides in other organs is represented by linear combinations of decaying exponential functions. In both the inhalation and ingestion models, cross-irradiation (irradiation of one organ by nuclides contained in another) is included.

The Th-232 was assumed to be in oxide form and a quality factor of 20 was used in the calculation in accordance with the recommendation of ICRP Publication 26, (ICRP, 1977). Radionuclide specific input parameters are summarized in Table A-11.